

Multigraph: Interactive Data Graphs on the Web

Mark Phillips
UNC Asheville's National Environmental Modeling and Analysis Center
Asheville, NC
mphillip@unca.edu

Devin Eldreth
UNC Asheville
devin.eldreth@gmail.com

The fields of weather and climate are full of time-series data. Observations, model output, forecasts --- almost all aspects of weather and climate involve time dependent data that is often presented in the form of a graph. With this in mind, and considering that the scientific community and the world at large has been turning to the web for several years now as a primary means of communication, there are surprisingly few good tools and techniques available for presenting time-series data on the web. The most common solution is to use a desktop tool such as Microsoft Excel or Matlab to create a graph which is saved as an image and then included in a web page like any other image. Although this is straightforward and simple, it limits the user to one particular view of the data, disconnects the graph from the data in a way that makes updating a graph with new data an often cumbersome manual process, and does not provide the reader with the ability to combine and compare data from separate sources.

This situation is somewhat analogous to the state of mapping before the advent of GIS. Maps existed only in printed form, and creating a map was a laborious process. There were many disparate sources of maps, and information from separate maps could only be combined manually by creating a new map. In the last several years, however, the world of mapping has experienced a revolution in the form of web-based and other interactive computer technologies, to the point that it is now commonplace, for example, for everyone from small children to grandparents to easily browse through gigabytes of geographic data to locate an aerial view of their house or neighborhood, or create and print a customized trip map complete with driving directions and time estimates.

Multigraph is a software tool that seeks to bring a similar ease of presentation and viewing to time series data. Multigraph displays interactive time-series data graphs in web pages that includes a simple way of configuring the appearance of the graph and the data to be included. It allows multiple data sources to be combined into a single graph, and allows the user to explore the data

interactively. Multigraph lets users explore and visualize "data space" in the same way that interactive mapping applications such as Google Maps facilitate exploring and visualizing geography.

Viewing a Multigraph graph is very simple and intuitive, and requires almost no instructions. Creating a new graph for inclusion in a web page involves writing a simple configuration file, and requires no programming. Multigraph is an Adobe Flash application and runs in any web browser that has Flash installed, which includes almost all browsers in Windows, Mac OS, and Linux. Multigraph can read data in a variety of formats, and can display data from a web service, allowing users to "surf" through large datasets, downloading only those the parts of the data that are needed for display.

Multigraph was created at UNC-Asheville's National Environmental Modeling and Analysis Center and NOAA's National Climatic Data Center (NCDC), and is freely available as open source software. This paper gives an introduction to viewing and creating graphs with Multigraph.

Online Version of this Paper

Multigraph is an interactive software tool that works in web pages, and the best way to experience it is to try it yourself in a web browser. If you would like to view the examples in this paper in a web browser so that you can get a feel for Multigraph yourself, go to <http://www.multigraph.org/ams2010paper>, which is an online version of the paper in which all the graphs are live.

Viewing Multigraph Graphs

Figure 1 shows a typical Multigraph graph displayed in a web page. It shows a graph of temperature data for May 5, 2009. The graph is interactive --- by clicking and dragging left or right with the mouse cursor over the graph, you can move backward or forward in time to

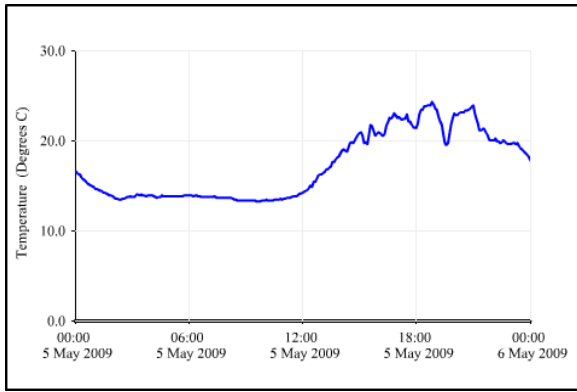


Figure 1: A Simple Multigraph Graph

show data from an earlier or later period. This is analogous to “panning” east or west in an interactive map. By holding down the shift key while click-dragging the mouse, you can zoom in or out, changing the time scale to show a shorter or longer time period.

Multigraph also allows you to pan and zoom along the vertical axis, moving up or down or changing the scale on the temperature axis. You indicate to Multigraph which axis you want to affect by crossing the mouse cursor over that axis; the most recent axis that you have crossed is called the “active” axis. The active axis appears thicker; in Figure 1, the horizontal axis is active. In Figure 2, the vertical axis is active. Figure 2 was created from the same graph as Figure 1, but after some panning and zooming on both the horizontal and vertical axes.

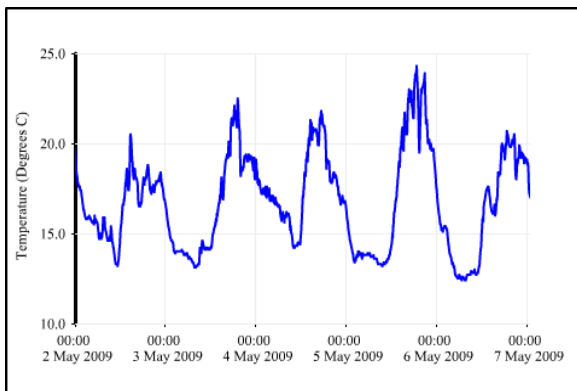


Figure 2: Same Graph as Figure 1 after Some Panning and Zooming

The example used to create Figures 1 and 2 includes roughly a week's worth of temperature data. The printed figures in the paper show only particular subsets of the data, but if you explore the interactive graph in the online version of this paper, you will see that the underlying data

covers a week's period. In this case, the entire underlying data set is downloaded to the web browser along with the graph, so that as soon as the graph appears in the web page, all the data is available for you to access as you pan or zoom around on the time axis. Many data sets, however, cover much longer periods of time and it is not feasible to download the entire dataset to the user's web browser. In these cases, Multigraph can be configured to display only a small piece of the data initially, and to fetch additional data as needed when the user pans or zooms along the time axis. Figure 3 shows roughly a month of temperature data. The interactive version of this figure looks exactly like Figure 1 when first viewed, in that it displays data for May 5, 2009. When you zoom out to view a longer time period, though, Multigraph contacts the web server to request whatever additional data is needed, and then draws the new parts of the graph once it receives that data from the server. For this figure, the data on the server covers nearly a two year period, and the interactive graph lets you explore as much or as little of that data as you want. The full data set is over 3 megabytes, and it would take a noticeable amount of time to download the entire data set to the browser. Since the graph only displays the data for one day initially, however, only that one day's data needs to be downloaded when the graph first appears. Multigraph then downloads whatever additional data is needed as you pan and/or zoom in the graph, always only downloading whatever is needed at the moment.

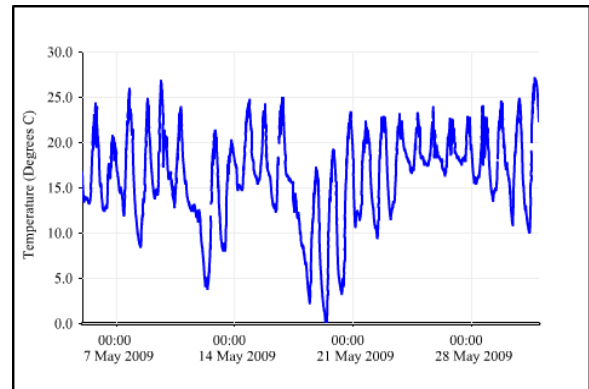


Figure 3: One Month of a Two-Year Data Set

The graphs we have seen so far show just a single variable, plotted with a simple line plot style. Multigraph can create much more complex plots, however, that combine multiple variables using a variety of plot styles. Figure 4 shows an example with 5 variables in the same plot. This plot uses multiple vertical axes to represent the distinct scales of the data; one axis is for temperature, one for precipitation, one for solar radiation, and one for wind

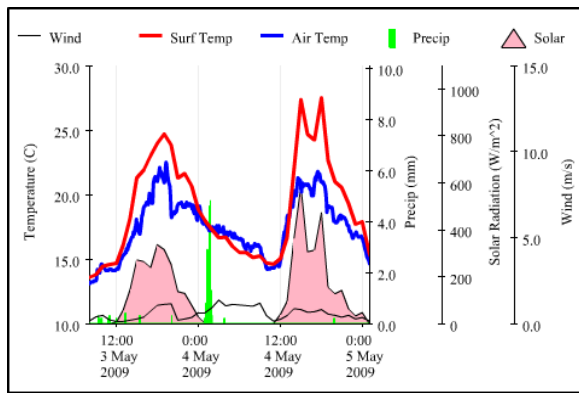


Figure 4: Multiple Variables in the Same Graph

speed. When you interact with the graph, each axis operates independently --- cross the mouse over an axis to make it active, and then click and drag to pan or zoom along that axis.

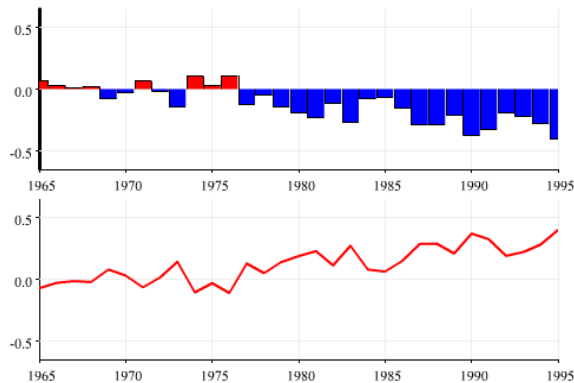


Figure 5: Separate Graphs with "Bound" Axes

Sometimes when multiple variables are displayed simultaneously it is better to show each one in its own graph, rather than overlaying them all on the same graph. Multigraph can be configured to create this kind of display, as shown in Figure 5. The figure shows 2 variables in 2 separate plots. Notice that if you pan along the time axis in any of these plots, all three graphs move together. This is called "axis binding" and is a Multigraph feature that allows separate axes that represent the same scale to be tied together.

Obtaining and Installing Multigraph

Multigraph is distributed free of charge under an open source license from the web site <http://www.multigraph.org>. The installation process consists simply of unpacking the downloaded files on a web server; it does not involve modifying or installing

any software on the server. The details are explained in the user guide, which is available on the Multigraph web site.

Creating Multigraph Graphs in Web Pages

Publishing a Multigraph graph in a web page is a straightforward two-step process that requires only a basic knowledge of HTML.

The first step is to insert a few lines into a web page's HTML to embed the Multigraph application in the page, and to tell Multigraph where to read a graph description file. The HTML involved is very simple and amounts to about 3 lines; the details are explained in the Multigraph user guide.

The second step involves creating a graph description file. Multigraph uses an XML format called "Multigraph XML", or "MUGL" for short. The purpose of a MUGL file is to specify the data to be graphed, as well as any preferences you have about how to display the data, axes, and other elements of the graph.

The simplest possible MUGL file is one that just gives the data to be plotted; Figure 6 shows an example:

```
<mugl>
  <data>
    <values>
      2000,36.7
      2001,49.5
      2002,55.9
      2003,55.8
      2004,53.5
      2005,60.6
      2006,55.6
      2007,54.8
      2008,48.7
    </values>
  </data>
</mugl>
```

Figure 6: A Simple MUGL File

Figure 7 shows the graph that Multigraph creates when given this MUGL file. In this case, the MUGL file gives only the data --- it contains no other information about the graph such as plot styles, colors, axes labels, and so on --- so Multigraph makes default choices for all these things.

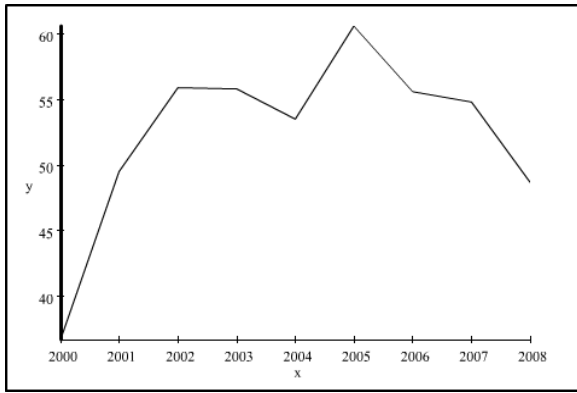


Figure 7: The Graph Resulting from the MUGL File in Figure 6

Figure 8 shows a slightly more involved MUGL file that customizes the graph somewhat. It includes commands that specify the format of the times printed along the horizontal axis, removes the title from that axis, add a title of "Temperature" for the vertical axis, and indicates that the data should be plotted with blue lines, and dots that are 2 pixels across. Figure 9 shows the graph that results.

Multigraph is very flexible and allows graphs to be customized in many ways. It supports a variety of plotting styles, has support for captions and legends, and allows detailed control over the positions of the axes. The data to be plotted may be either included directly in the MUGL file, as in the above examples, or given in a separate CSV file. Multigraph can also read data from a web service, as described in Figure 3 above. When using a web service to supply the data to be plotted, the <data> section of the MUGL file specifies the address of the web service, rather than including the data directly. When this is done, Multigraph issues requests to the server to retrieve the data. It only retrieves as much data as it needs to display the time region in view, creating more requests if and when the user pans or zooms to view a region for which it does not yet have data.

The details of all of Multigraph's configuration options, and the syntax of the corresponding MUGL commands, are documented in the Multigraph user guide which is available at the Multigraph web site, <http://www.multigraph.org>.

```
<mugl>
  <horizontalaxis type="datetime" >
    <labels format="%d %n %H:00"
      spacing="1D 12H 6H 4H 2H 1H"/>
    <title/>
  </horizontalaxis>
  <verticalaxis type="number"
    min="17.0" max="20.5">
    <title angle="90">temp</title>
  </verticalaxis>
  <plot>
    <renderer type="line">
      <option name="linecolor"
        value="blue"/>
      <option name="dotcolor"
        value="blue"/>
      <option name="dotsize"
        value="2"/>
    </renderer>
  </plot>
  <data>
    <variables>
      <variable id="time"
        type="datetime"/>
      <variable id="temp"/>
    </variables>
    <values>
      200905280000,20.0
      200905280100,19.0
      200905280200,18.9
      200905280300,18.5
      200905280400,18.2
      200905280500,17.9
      200905280600,17.5
      200905280700,17.5
      200905280800,17.7
      200905280900,17.8
      200905281000,17.6
      200905281100,17.5
      200905281200,17.7
    </values>
  </data>
</mugl>
```

Figure 8: A More Detailed MUGL File

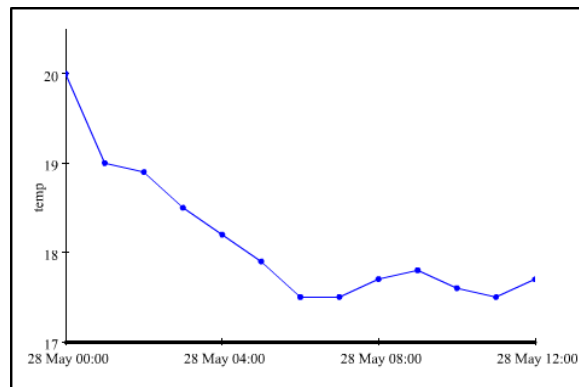


Figure 9: The Graph Resulting from the MUGL File in Figure 8

Using the Online “Tester”

The Multigraph web site has an interactive "tester" page (<http://www.multigraph.org/tester>) that you can use to test a MUGL file and see the resulting graph, or get detailed error messages if it contains errors. For example, if you copy and paste the MUGL from Figure 8 into the input box on the tester page and click the “Submit MUGL” button, you should see a graph like Figure 9. This tester can be very useful when developing a new graph.

Embedding Multigraph in a Flex Application

Adobe Flex is a powerful software environment for creating web applications. Flex applications run in any browser that has the Adobe Flash player installed, and they are becoming more and more widely used to create a rich web experience for the user. In addition to appearing in a web page as described above, Multigraph can also be used as a component in a Flex application, so that Multigraph graphs can appear anywhere inside the application.

One particularly useful example of this is with mapping applications. ***Figure 10*** shows a web page displaying a Flex application that uses the free Google Maps Flex library together with Multigraph to create an interactive map showing the locations of NOAA's Climate Reference Network (<http://www.ncdc.noaa.gov/crn>) monitoring stations. The map is fully interactive like any Google Maps map, with the addition that if you click on one of the stations, a popup window appears showing a Multigraph graph containing the most recent data from that station. The graph uses a web service to fetch data from NCDC's servers, and you can pan and zoom in time to see as much of the station's data as you want. If you click on another station to pop up a second graph, the two graphs move together as you interact with them.

Why Multigraph?

Multigraph was created to provide a simple yet flexible way to publish interactive data graphs in web pages, without the need for any programming. There are variety of programming tools that support the creation of web-based data graphs, such as the Google Chart API, Flex Charting components, JFreeChart, and many others, but they require custom programming. Multigraph graphs can be created without any programming or the need for any software development environment; all that is needed is a text editor to create a MUGL file.

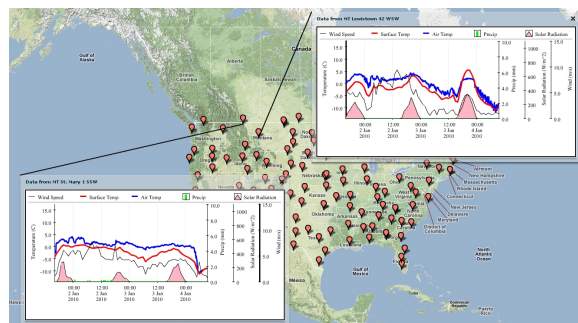


Figure 10: (<http://crn.multigraph.org>) Multigraph Combined with the Google Maps Flex API

A guiding principle in the development of Multigraph has been the separation of the description of a graph from the data shown in the graph. Most of the examples in this paper have the data embedded in the MUGL file, but that is because we wanted to keep the examples simple. In real-world applications, the data that is displayed in a Multigraph graph usually comes from a web service, or an external data file. The commands in the MUGL file describe how to display the data but don't include the data itself. This makes it very easy to reuse a graph description file once it has been written, or to update the data if and when new data becomes available, without having to change the graph description file.

Getting Involved

Multigraph is an ongoing project and we encourage anyone to download it, play with it, and use it to put interactive graphs on the web. If you have questions or want to discuss issues related to using Multigraph with other Multigraph users, we invite you to join the Multigraph mailing list; details are available at <http://www.multigraph.org>.