



Getting Started with S-PLUS® 8 for Windows®

May 2007

Insightful Corporation
Seattle, Washington

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S-PLUS BOOKS

The S-PLUS[®] documentation includes books to address your focus and knowledge level. Review the following table to help you choose the S-PLUS book that meets your needs. These books are available in PDF format in the following locations:

- In your S-PLUS installation directory (**\$HOME\help** on Windows, **\$HOME/doc** on UNIX/Linux).
- In the S-PLUS Workbench, from the **Help ► S-PLUS Manuals** menu item.
- In Microsoft[®] Windows[®], in the S-PLUS GUI, from the **Help ► Online Manuals** menu item.

S-PLUS documentation.

Information you need if you...	See the...
Are new to the S language and the S-PLUS GUI, and you want an introduction to importing data, producing simple graphs, applying statistical models, and viewing data in Microsoft Excel [®] .	<i>Getting Started Guide</i>
Are a system administrator or a licensed user and you need guidance licensing your copy of S-PLUS and/or any S-PLUS module.	<i>S-PLUS licensing Web site</i> <i>keys.insightful.com/</i>
Are a new S-PLUS user and need how to use S-PLUS, primarily through the GUI.	<i>User's Guide</i>
Are familiar with the S language and S-PLUS, and you want to use the S-PLUS plug-in, or customization, of the Eclipse Integrated Development Environment (IDE).	<i>S-PLUS Workbench User's Guide</i>
Have used the S language and S-PLUS, and you want to know how to write, debug, and program functions from the Commands window.	<i>Programmer's Guide</i>

S-PLUS documentation. (Continued)

Information you need if you...	See the...
Are familiar with the S language and S-PLUS, and you want to extend its functionality in your own application or within S-PLUS.	<i>Application Developer's Guide</i>
Are familiar with the S language and S-PLUS, and you are looking for information about creating or editing graphics, either from a Commands window or the Windows GUI, or using S-PLUS-supported graphics devices.	<i>Guide to Graphics</i>
Are familiar with the S language and S-PLUS, and you want to use the Big Data library to import and manipulate very large data sets.	<i>Big Data User's Guide</i>
Want to download or create S-PLUS packages for submission to the Comprehensive S Archival Network (CSAN) site, and need to know the steps.	<i>Guide to Packages</i>
Are looking for categorized information about individual S-PLUS functions.	<i>Function Guide</i>
If you are familiar with the S language and S-PLUS, and you need a reference for the range of statistical modelling and analysis techniques in S-PLUS. Volume 1 includes information on specifying models in S-PLUS, on probability, on estimation and inference, on regression and smoothing, and on analysis of variance.	<i>Guide to Statistics, Vol. 1</i>
If you are familiar with the S language and S-PLUS, and you need a reference for the range of statistical modelling and analysis techniques in S-PLUS. Volume 2 includes information on multivariate techniques, time series analysis, survival analysis, resampling techniques, and mathematical computing in S-PLUS.	<i>Guide to Statistics, Vol. 2</i>

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OVERVIEW

S-PLUS is designed to work seamlessly with the software you already use. You can import data from and export data to many sources, including spreadsheets such as Excel and Lotus, databases such as Access, analytical software such as SAS and SPSS, and the financial databases Bloomberg, LIM, and FAME. Once you have accessed your data, you can analyze and explore them.

This quick tour briefly introduces you to many of the most commonly used procedures in S-PLUS.

GETTING DATA

In this exercise, walk through an S-PLUS session using some built-in sample data to help you decide which new car you should buy.

1. From the main menu, choose **Data ► Select Data** to display the **Select Data** dialog box, as shown in Figure 1.1.

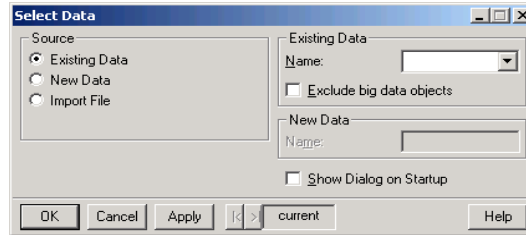


Figure 1.1: The *Select Data* dialog box.

2. In the **Source** group, **Existing Data** is selected by default. In the **Existing Data** group, type **fuel.frame** in the **Name** box. (Disregard the **Exclude big data objects** check box)
3. Click **OK** to load the data into a **Data** window.

		1	2	3	4	5	6
		Weight	Disp.	Mileage	Fuel	Type	
1	Eagle Summit 4	2560.00	97.00	33.00	3.03	Small	
2	Ford Escort 4	2345.00	114.00	33.00	3.03	Small	
3	Ford Festiva 4	1845.00	81.00	37.00	2.70	Small	
4	Honda Civic 4	2260.00	91.00	32.00	3.13	Small	
5	Mazda Protege 4	2440.00	113.00	32.00	3.13	Small	
6	Mercury Tracer 4	2285.00	97.00	26.00	3.85	Small	
7	Nissan Sentra 4	2275.00	97.00	33.00	3.03	Small	
8	Pontiac LeMans 4	2350.00	98.00	28.00	3.57	Small	
9	Subaru Loyale 4	2295.00	109.00	25.00	4.00	Small	
10	Subaru Justy 3	1900.00	73.00	34.00	2.94	Small	
11	Toyota Corolla 4	2390.00	97.00	29.00	3.45	Small	
12	Toyota Tercel 4	2075.00	89.00	35.00	2.86	Small	
13	Volkswagen Jetta 4	2330.00	109.00	26.00	3.85	Small	
14	Chevrolet Camaro V8	3320.00	305.00	20.00	5.00	Sporty	
15	Dodge Daytona	2885.00	153.00	27.00	3.70	Sporty	
16	Ford Mustang V8	3310.00	302.00	19.00	5.26	Sporty	
17	Ford Probe	2695.00	133.00	20.00	3.23	Sporty	

Figure 1.2: The *fuel.frame* data.

The `fuel.frame` data set consists of five data columns plus a column of row names:

- `Weight`: Automobile weight in pounds
- `Disp.`: Engine displacement in cubic inches
- `Mileage`: Mileage in miles per gallon
- `Fuel`: $100/\text{Mileage}$
- `Type`: Category of vehicle (Large, Medium, Small, Compact, Sporty, Van)


There are eight different column types in S-PLUS: character, complex, double, factor, integer, logical, single, and `timeDate`. To see a `DataTip` displaying a column's type, pause your cursor over the column number.

4	5	6
Fuel	Type	factor
3.03	Small	

Notice that `Type` is a factor column representing *categorical* data.

CREATING A 2D GRAPH

Creating a graph in S-PLUS is easy: simply select your data columns and click a plot button.

1. Select all the columns of `fuel.frame` (from `Weight` to `Type`) by clicking and dragging the mouse across the column headers.
2. On the **Standard** toolbar, click the **2D Plots** button  to open a palette of available 2D plot types.

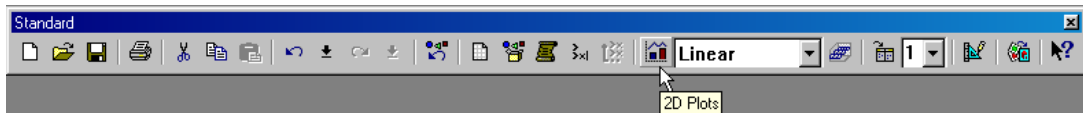


Figure 1.3: *The 2D Plots button on the Standard toolbar.*

3. Now click the **Scatter Matrix** button  on the **Plots 2D** palette.

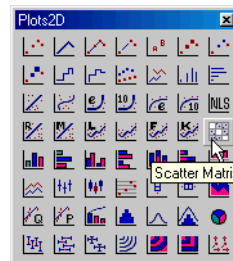


Figure 1.4: *The Scatter Matrix button on the Plots 2D palette.*

Note

S-PLUS palettes and toolbars can be docked in place, dragged and dropped to create a floating palette, or resized by dragging an edge.

As shown in Figure 1.5, the resulting scatterplot matrix displays each column of data against the other selected columns. For example, to see how `Mileage` and `Fuel` are related, read across from `Mileage` and

above Fuel to see the plot. The plot shows that Mileage and Fuel are directly related. You can also see a strong relationship between Mileage and Weight: heavier cars have lower mileage.

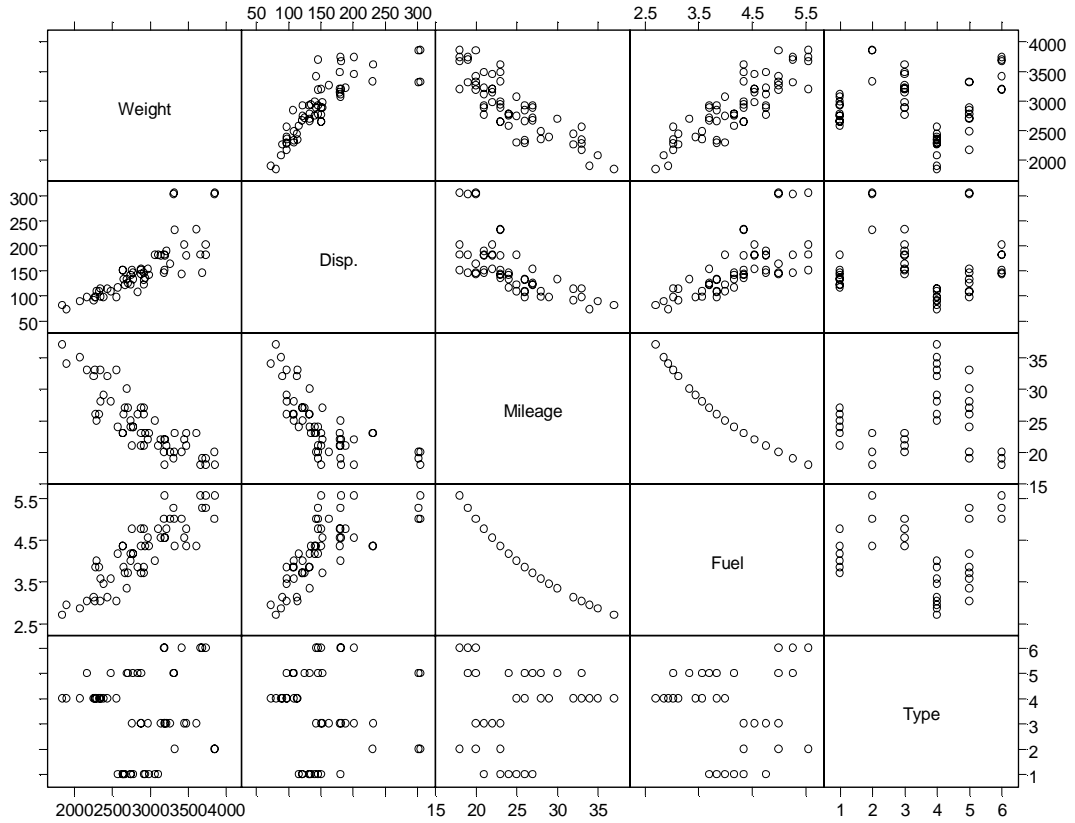



Figure 1.5: The scatterplot matrix shows a number of strong relationships.

PERFORMING A LINEAR REGRESSION

In this exercise, examine the relationship between Weight and Mileage more extensively.

1. Close the **Graph Sheet** containing the scatterplot matrix. You do not need to save it.
2. In the **Data** window, click the column header of **Weight** and then CTRL-click the column header of **Mileage** so that both columns are highlighted.
3. Now click the **Linear Fit** button  on the **Plots 2D** palette.

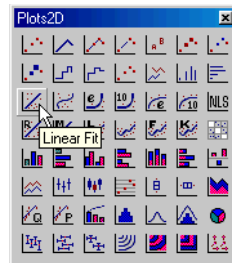


Figure 1.6: *The Linear Fit button on the Plots 2D palette.*

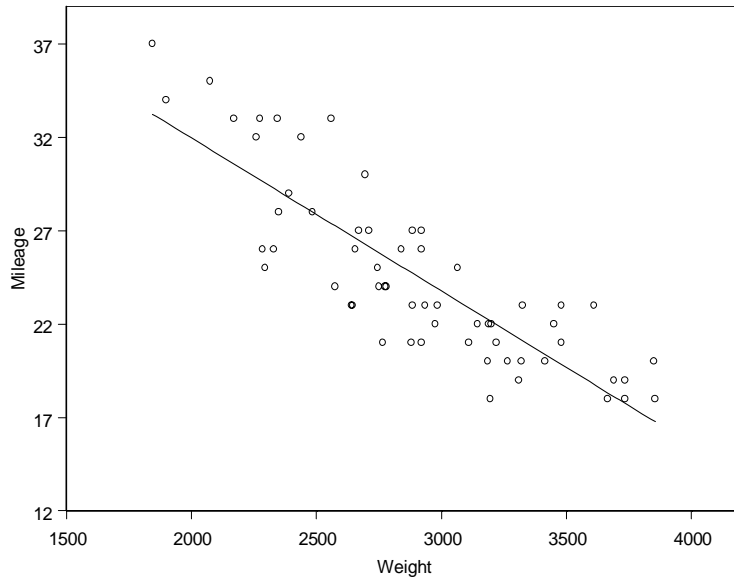


Figure 1.7: *Linear fit of Mileage vs. Weight.*

As shown in Figure 1.7, this linear fit shows an obvious relationship between an increase in Weight and a decrease in Mileage.

To examine how vans or compact cars fit into this example, we can use Trellis graphics to condition Weight and Mileage on a third variable, Type.

4. From the main menu, choose **Window ► Tile Vertical** (or press CTRL-SHIFT-V) to vertically tile the **Graph Sheet** and **Data** window side by side.
5. Select the Type column by clicking its header. (With your windows tiled vertically, you may have to use the slider at the bottom of the **Data** window to locate the Type column.)
6. Position your mouse within the data area (not the header area) of the Type column; the cursor becomes a white pointer arrow. (If positioned in the column header, the cursor becomes a black down arrow.)
7. Now click and drag the column to the top of the **Graph Sheet** until a rectangle marked by dashed lines appears. A boxed plus sign beneath the mouse cursor indicates that you have positioned the cursor correctly, as shown in Figure 1.8. Release the mouse button to drop the column into this rectangle and create the Trellis graph.

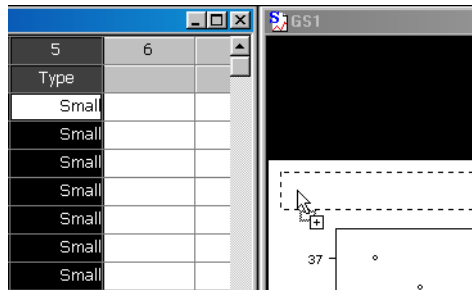


Figure 1.8: Drag and drop to create Trellis graphs.

The resulting plot is shown in Figure 1.9. Notice that the data are divided into subsamples and conditioned by Type. Now you can see additional relationships:

- Sporty cars, normally assumed to be gas guzzlers, actually have among the highest mileage, along with Small cars.

- Compact and Medium cars, often touted for higher mileage, get gas mileage similar to Large cars.

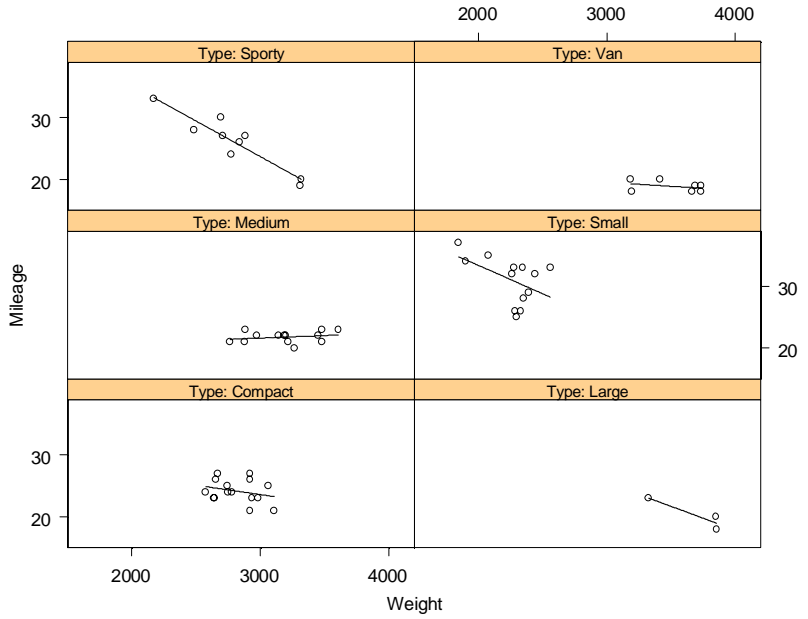



Figure 1.9: A Trellis view of the `fuel.frame` data.

IDENTIFYING AND LABELING DATA POINTS

In this exercise, identify which cars have the best and worst mileage by labeling the data points.

1. Point the mouse cursor at any data point in the graph. A DataTip (similar to a ToolTip) appears, displaying the vehicle's model, weight, and mileage.
2. Making sure that the **Graph Sheet** is in focus (so that the **Graph** toolbar is displayed), click the **Graph Tools** button  on the **Graph** toolbar to open the **Graph Tools** palette, as shown in Figure 1.10.

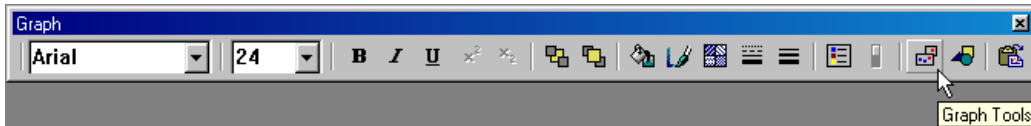



Figure 1.10: The **Graph Tools** button on the **Graph** toolbar.

3. Click the **Label Point** button  on the **Graph Tools** palette.

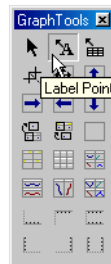
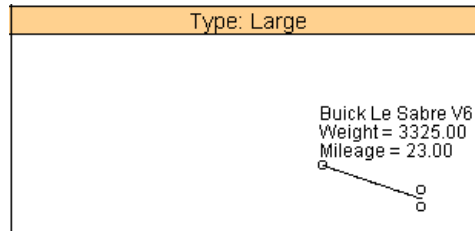


Figure 1.11: The **Label Point** button on the **Graph Tools** palette.

- Click any data point. The data point is labeled with the car description (the row name) and the values of the plotted columns at that point. For example, if you click the uppermost data point in the Large cars panel, you see the following label:



SHIFT-click additional points to label multiple points at once.

- Click the **Select Tool** button  on the **Graph Tools** palette and delete the labels by selecting them and pressing DELETE.

Next, change the contents of the DataTips and labels.


- Right-click any data point in the plot and select **Data to Plot** from the shortcut menu.
- In the **DataTips and Point Labels** group, expand the **Column** list.
- Click <ROWNAMES> and then CTRL-click **Disp**.
- Click **OK**.

The model name and engine displacement are now displayed in the DataTips.

EDITING A GRAPH

Imagine that you want to include your graph in a report or presentation. In that case, you might want to further modify the graph's attributes.

In S-PLUS, graphics are object-oriented, which means you have complete control over every detail. You can easily modify graph objects using shortcut menus, dialog boxes, or the toolbar.

1. On the graph, click the x -axis title and then SHIFT-click the y -axis title to select both titles. Each axis title is surrounded by green knobs, indicating that it is selected.
2. Use the **Graph** toolbar to change the font size to **20**.
3. Click any data point to select the plot. A single green square appears on the plot indicating that it is selected.
4. Change the plot color to red. On the **Graph** toolbar, click the **Line Color** button  and select **Red** from the dropdown menu (see Figure 1.12).

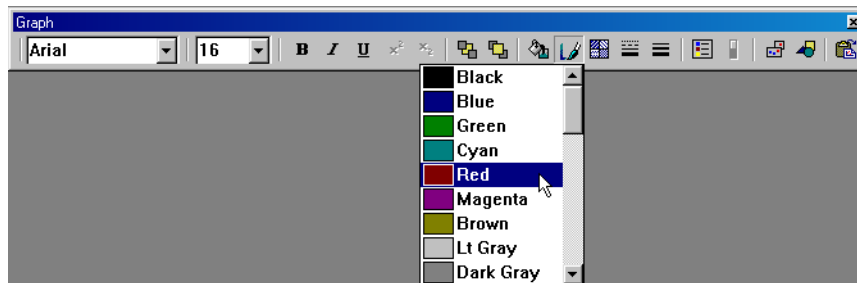
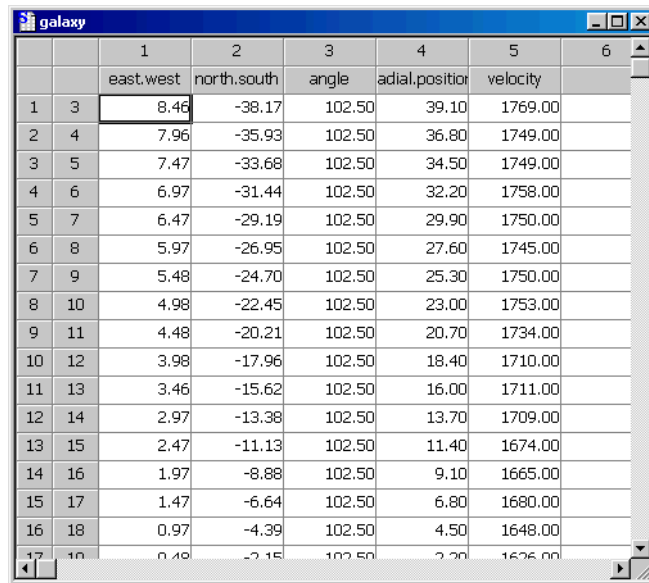


Figure 1.12: The **Line Color** button can be used to change text color as well as line color.

CREATING A 3D GRAPH

S-PLUS offers a variety of 3D plot types for powerful data visualization. First, load some 3D data.

1. Close all open windows and palettes. (You do not need to save any **Graph Sheets**.)
2. From the main menu, choose **Data ► Select Data** to display the **Select Data** dialog box.
3. In the **Existing Data** group, type **galaxy** in the **Name** box.
4. Click **OK** to load the data into a **Data** window.




		1	2	3	4	5	6
		east.west	north.south	angle	adial.position	velocity	
1	3	8.46	-38.17	102.50	39.10	1769.00	
2	4	7.96	-35.93	102.50	36.80	1749.00	
3	5	7.47	-33.68	102.50	34.50	1749.00	
4	6	6.97	-31.44	102.50	32.20	1758.00	
5	7	6.47	-29.19	102.50	29.90	1750.00	
6	8	5.97	-26.95	102.50	27.60	1745.00	
7	9	5.48	-24.70	102.50	25.30	1750.00	
8	10	4.98	-22.45	102.50	23.00	1753.00	
9	11	4.48	-20.21	102.50	20.70	1734.00	
10	12	3.98	-17.96	102.50	18.40	1710.00	
11	13	3.46	-15.62	102.50	16.00	1711.00	
12	14	2.97	-13.38	102.50	13.70	1709.00	
13	15	2.47	-11.13	102.50	11.40	1674.00	
14	16	1.97	-8.88	102.50	9.10	1665.00	
15	17	1.47	-6.64	102.50	6.80	1680.00	
16	18	0.97	-4.39	102.50	4.50	1648.00	
17	19	0.48	-2.15	102.50	2.20	1626.00	

Figure 1.13: *The galaxy data.*

The galaxy data set contains measurements of the radial velocity of a spiral galaxy measured at 323 points in the sky.

5. Select the data columns `east.west`, `north.south`, and `velocity` by CTRL-clicking each column header.

6. On the **Standard** toolbar, click the **3D Plots** button  to open a palette of available 3D plot types.

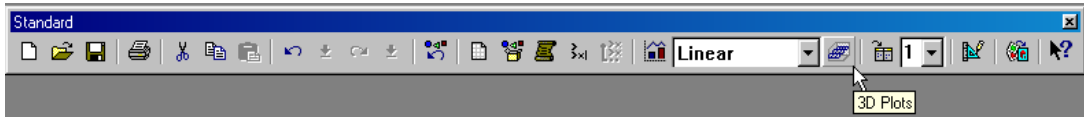


Figure 1.14: The **3D Plots** button on the **Standard** toolbar.

7. Now click the **3D Scatter** button  on the **Plots 3D** palette.



Figure 1.15: The **3D Scatter** button on the **Plots 3D** palette.

The resulting graph is shown in Figure 1.16.

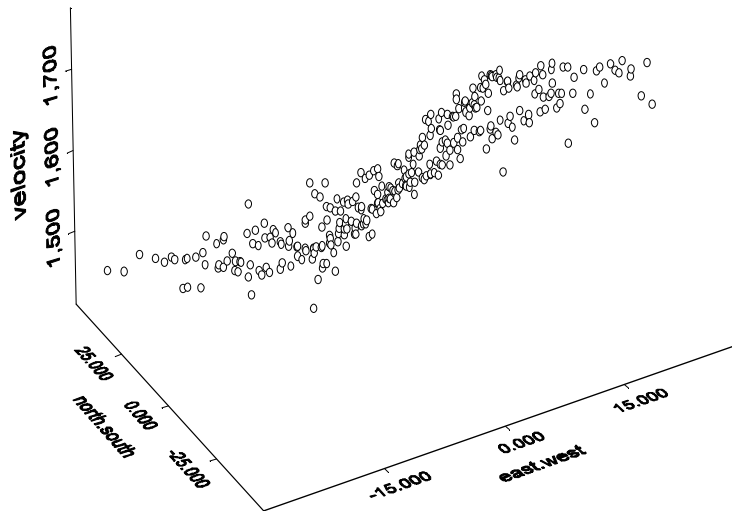



Figure 1.16: A three-dimensional scatter plot of the galaxy data.

You can interactively rotate the 3D graph, both horizontally and vertically.

8. Click an empty space (but not a data point) within the plot area to select the invisible 3D *workbox*. Four green circles and a green triangle appear, indicating the *workbox* is selected.
9. Drag one of the green circles to rotate the plot horizontally. When you release the mouse, the graph is redrawn at the new perspective. The green triangle can be dragged up and down to rotate the graph vertically.
10. Now click one of the plotted data points to select the scatter plot. A single green box appears, indicating that the plot is selected.
11. Click the **4 Panel Rotation** button  on the **Plots 3D** palette. The resulting plot is shown in Figure 1.17.

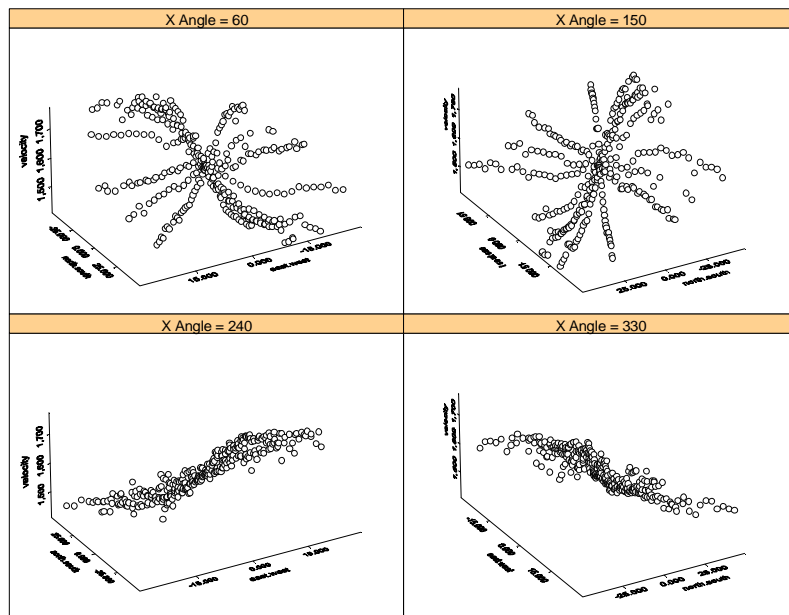



Figure 1.17: Four-panel rotation of the galaxy data.

12. To rotate the graph, select the 3D *workbox* in the lower left panel. All the panels will rotate together so that you can view your graph from different angles.

VIEWING OBJECTS AND DATABASES

The S-PLUS **Object Explorer** is a simple but powerful interface for viewing, editing, manipulating, and organizing your S-PLUS objects.

1. Open the **Object Explorer** by clicking the **Object Explorer** button  on the **Standard** toolbar.

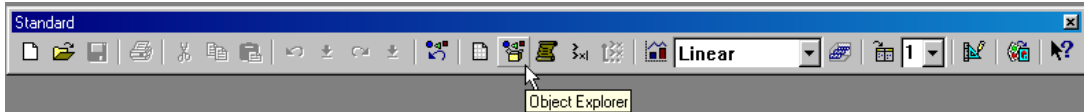


Figure 1.18: *The **Object Explorer** button on the **Standard** toolbar.*

The **Object Explorer** uses folders to organize your objects. The first time you open the **Object Explorer**, five default folders appear, labeled **Data**, **Graphs**, **Reports**, **Scripts**, and **SearchPath** (see Figure 1.19).

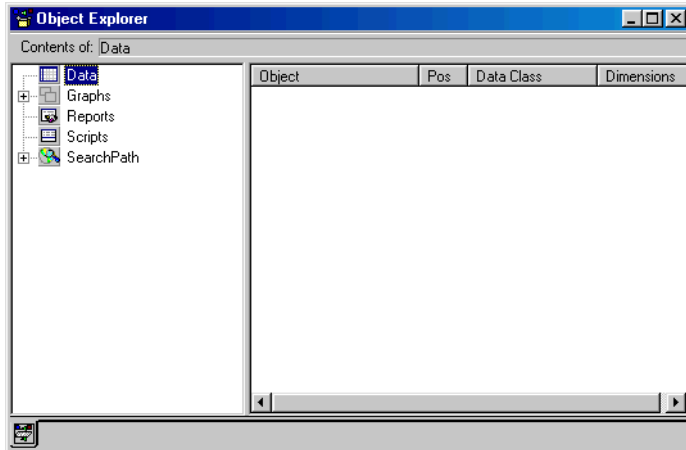


Figure 1.19: *The **Object Explorer**.*

Use the **Object Explorer** to locate the two built-in data sets, `fuel.frame` and `galaxy`, that you have used in this quick tour.

2. In the left pane of the **Object Explorer**, click the plus (+) sign to the left of the **SearchPath** icon to expand the **SearchPath** folder.

3. Select the **data** subfolder in the left pane to display its contents in the right pane.
4. Scroll through the right pane to locate the sample data sets `fuel.frame` and `galaxy`.

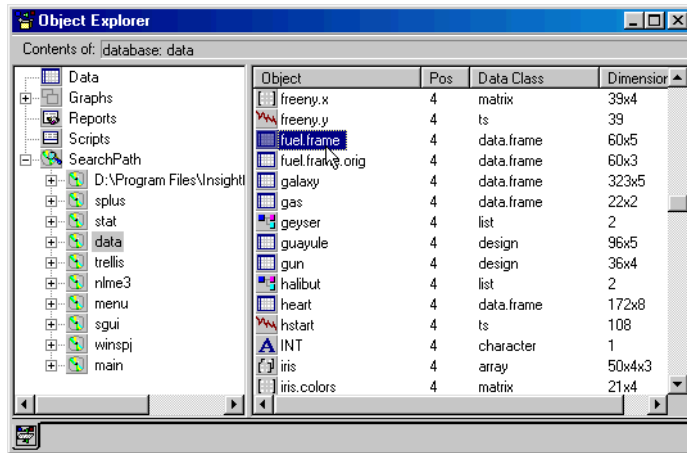


Figure 1.20: *The contents of the **data** database displayed in the right pane.*

The objects displayed in the **SearchPath** folder are S-PLUS databases. The first database in the search path is called the *working data* and is the database in which S-PLUS automatically saves the data you create and modify during a session. The remaining databases in the search path are the *system databases*, which contain all the functions and data objects that come with S-PLUS.

The **SearchPath** folder is handy for displaying the contents of any S-PLUS database. By selecting a database in the left pane of the **Object Explorer**, you can view its contents in the right pane.

ORGANIZING YOUR WORK

By creating folders in the **Object Explorer**, you can organize the work you do in S-PLUS. In this exercise, insert a new folder to “contain” those objects associated with our current analysis.


1. Deselect any selected folders or objects by clicking in the white space of the left pane of the **Object Explorer**.
2. Click the **New Folder** button  on the **Object Explorer** toolbar, as shown in Figure 1.21.



Figure 1.21: *The **New Folder** button on the **Object Explorer** toolbar.*

3. Name the folder **Galaxy Project**.
4. Display the contents of the **data** database by selecting it in the left pane under **Search Path**.
5. In the right pane, select the **galaxy** data object by clicking its icon; then drag and drop it into the **Galaxy Project** folder you just created.
6. Click the **Graphs** folder icon to select it; the **Graph Sheet** (GS1) open in your S-PLUS session appears in the right pane. (Just as with any folder, you can click the plus (+) sign to the left of the **Graphs** folder icon to expand your **Graph Sheet** in the left pane.)
7. Drag and drop the GS1 object from the right pane into the **Galaxy Project** folder.

8. Select the **Galaxy Project** folder to view its contents in the right pane, as shown in Figure 1.22.

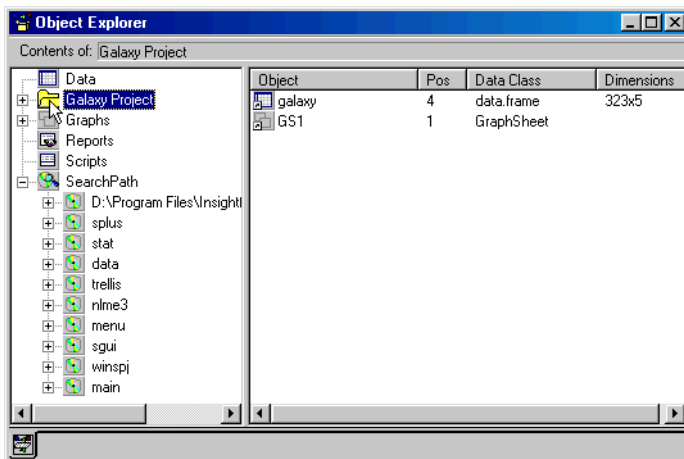


Figure 1.22: Use the *Object Explorer* to view and organize the contents of your session.

EXTENDED TOUR

2

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IMPORTING A FILE

We begin this extended example by importing data from a SAS file. If you have any windows or palettes open from the preceding tutorial, close them before continuing.

To import the data:

1. From the main menu, choose **File ► Import Data ► From File**. The **Import From File** dialog box opens, as shown in Figure 2.1.

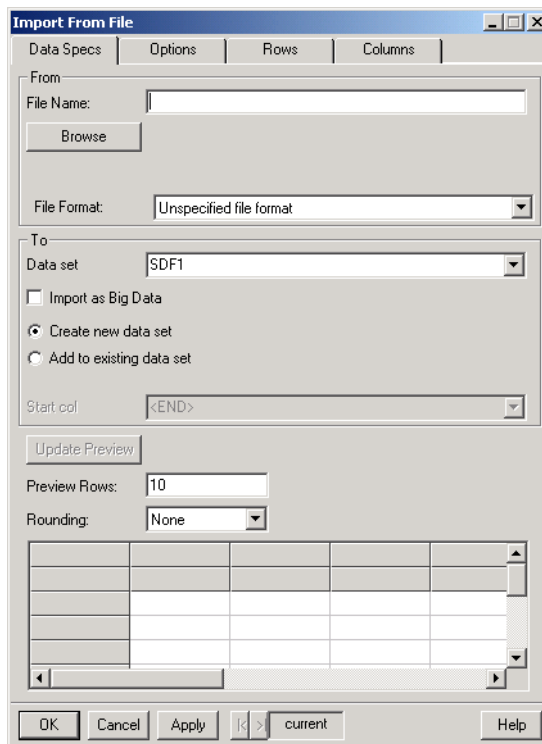
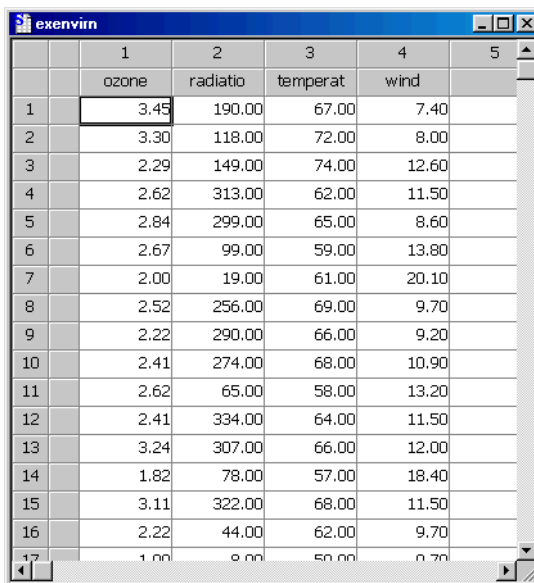


Figure 2.1: *The Import From File dialog box.*

2. Click **Browse**, navigate to the `\library\example5` folder in your S-PLUS program folder, select `exenvirn.sd2` as the file to import, and click **OK**.
3. Click **OK** in the dialog box to import the data.



The screenshot shows a window titled 'exenvirn' containing a data table. The table has five columns labeled 1 through 5, with corresponding headers 'ozone', 'radiatio', 'temperat', and 'wind'. The data rows are numbered 1 through 17. The values in the 'ozone' column range from 1.82 to 3.45, 'radiatio' from 44.00 to 334.00, 'temperat' from 57.00 to 74.00, and 'wind' from 7.40 to 20.10.

	1	2	3	4	5
	ozone	radiatio	temperat	wind	
1	3.45	190.00	67.00	7.40	
2	3.30	118.00	72.00	8.00	
3	2.29	149.00	74.00	12.60	
4	2.62	313.00	62.00	11.50	
5	2.84	299.00	65.00	8.60	
6	2.67	99.00	59.00	13.80	
7	2.00	19.00	61.00	20.10	
8	2.52	256.00	69.00	9.70	
9	2.22	290.00	66.00	9.20	
10	2.41	274.00	68.00	10.90	
11	2.62	65.00	58.00	13.20	
12	2.41	334.00	64.00	11.50	
13	3.24	307.00	66.00	12.00	
14	1.82	78.00	57.00	18.40	
15	3.11	322.00	68.00	11.50	
16	2.22	44.00	62.00	9.70	
17	1.00	8.00	50.00	0.70	

Figure 2.2: *The imported exenvirn data.*

The exenvirn data set contains measurements on ozone concentration, solar radiation, daily maximum temperature, and wind speed on 111 days in 1973 in the New York metropolitan area.

EDITING VARIABLE NAMES AND ADDING DESCRIPTIONS

Variable Names

Notice that the imported SAS file has variable names that are at most eight characters long. In S-PLUS, variable names are more flexible, so in this exercise, modify the variable names before creating a graph.

1. In the **Data** window, double-click the column name for column 2 (**radiatio**), type **Radiation**, and then click **OK**.
2. Change the column name for column 3 from **temperat** to **Temperature**.
3. For consistency, change the **ozone** and **wind** column names to **Ozone** and **Wind**, respectively.


Column Descriptions

You can store more detailed information about your data set in column descriptions. Column descriptions are automatically used as axis titles when graphing the data.

4. Right-click anywhere in the **Radiation** column to display the shortcut menu for the column. Select **Properties**.
5. In the **Description** box, type **Solar Radiation (langleys)** and click **OK**.

CREATING A 2D GRAPH

You are ready to visualize the data. First, create a local regression plot of the data.

1. In the **Data** window, select the **Radiation** column and then CTRL-click to select **Ozone** so that both columns are highlighted. (The first column will be the x data, and the second will be the y data.)
2. Click the **2D Plots** button to open the **Plots 2D** palette.
3. Click the **Loess** button  on the **Plots 2D** palette. A locally weighted, least squares regression is calculated, and the plot is created.
4. Close the **Plots 2D** palette.
5. Click the maximize button in the upper right corner of the **Graph Sheet**.
6. Right-click any data point (or the smoothed line) and select **Smooth/Sort** from the plot's shortcut menu.

Note

If you do not see a **Smooth/Sort** option in the shortcut menu, you probably selected another graph object. Try again, making sure you click a data point and not the plot area, an axis, or an axis label. S-PLUS indicates selected graphics objects with green knobs. Try clicking different parts of the graph (axis, labels, data, etc.) to see how different graph objects are highlighted with green knobs when they have been selected. See *Selecting Graph Objects* on page 74 for more details.

7. Try different levels of smoothing. In the **Loess/Friedman Specs** group, enter values between 0.1 and 0.9 in the **Span** box and click **Apply**.
8. Reset the **Span** to **Auto** and click **OK**.

CHANGING GRAPH FEATURES

S-PLUS gives you unparalleled control over every detail of your graph, right down to the thickness of the tick marks. You can control all individual line thicknesses, symbol sizes, fonts, colors, titles, tick marks, and axis labels. Additionally, you can create multiple lines of text for comments, titles, and tick labels. Superscript and subscript options are conveniently located on the **Graph** toolbar for quick access so editing text or equations is easy.

Axes and Labels

1. Click the y axis to select it. (A square green knob appears on the center of the axis if you have properly selected it.)
2. CTRL-click the x axis to select it.
3. From the main menu, choose **Format ► Selected Objects**. The **Modify All Selected Objects (if applicable)** dialog box opens, displaying the **Display/Scale** page.
4. In the **Color** box, select **Lt Gray**.
5. In the **Frame** box, select **With ticks**.
6. Click the **Grids/Ticks** tab. In the **Major Ticks** group, in the **Weight** box, select **1**.
7. In the **Tick Position** box, select **In**.
8. Click **OK**.

In the following steps, change the y -axis title.

9. Click once to select the axis title (green knobs surround the axis title when it is selected), and then click once more to open an in-place edit box.
10. In the text edit box, type **Ozone Concentration**. Do not press ENTER; rather, click outside the box to accept the change.

Plot Properties

11. Right-click any data point (or the smoothed line) and select **Line** from the plot's shortcut menu. (A green knob appears at the bottom of the graph indicating the plot object is selected.)
12. In the **Color** box, select **Black**; in the **Weight** box, select **2**.


- Click the **Symbol** tab to display the **Symbol** page of the dialog box. In the **Style** box, select **Circle, Solid**. In the **Color** box, select **Red**.
- Click **OK**.

Titles

In this section, insert a main title at the top of the graph.

- From the main menu, choose **Insert ► Titles ► Main**.
- In the resulting text edit box, type **The Relationship Between Radiation and Ozone**. Do not press ENTER; rather, click outside the title to close the text box.

Use the toolbar to change the font, font size, and color of any text objects in your graph.

- Select the main title and use the toolbar to specify a font size of **20**.
- Click the **Line Color** button  on the **Graph** toolbar and change the text color to **Blue**.

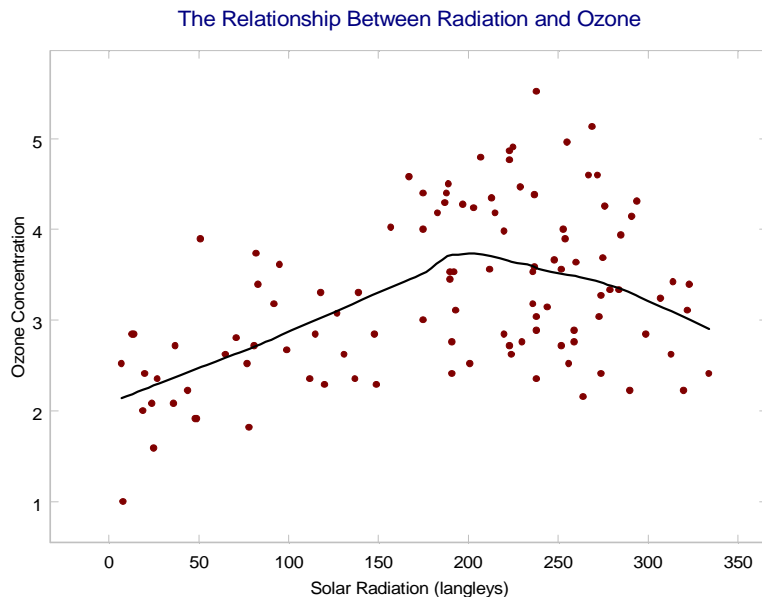


Figure 2.3: After you change the graph, it looks like this.

Do not close the **Graph Sheet** or **Data** window; you will use them again shortly.

USING TRELLIS GRAPHICS FOR MULTIPANEL CONDITIONING

Suppose you have a data set with multiple variables, and you want to see how plots of two variables change with variations in one or more conditioning variables. Trellis graphics are designed to display your data in a series of panels conditioned upon different values of one or more specified variables. Each panel contains a subset of the original data corresponding to intervals of the conditioning variables.

Most S-PLUS graphs can be conditioned. The data columns used for each plot and for the conditioning variable(s) must be of equal length. By default, the axis specifications and panel display attributes (for example, fill color) are identical for each panel.

Apply multipanel conditioning to our previously created loess plot.

1. Make sure that only the windows containing the `exenvirn` data and your **Graph Sheet** are open. From the main menu, choose **Window ► Tile Vertical**.
2. In the **Data** window, select Temperature and then CTRL-click to select Wind.

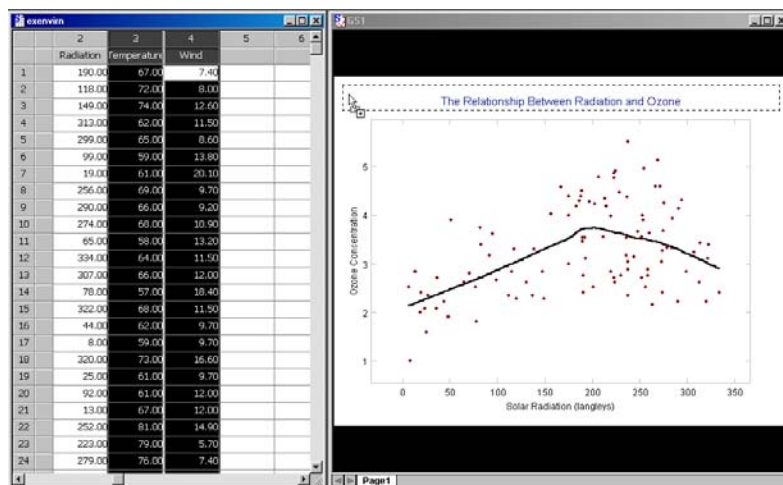


Figure 2.4: *Temperature and Wind are dragged to the rectangular drop target at the top of the graph.*

- As illustrated in Figure 2.4, click and hold the mouse in the data area of the columns and then drag and drop them onto the rectangular drop target that appears at the top of the graph.

The resulting Trellis graph (see Figure 2.5) shows how the dependence of Ozone on Radiation varies according to levels of Wind and Temperature.

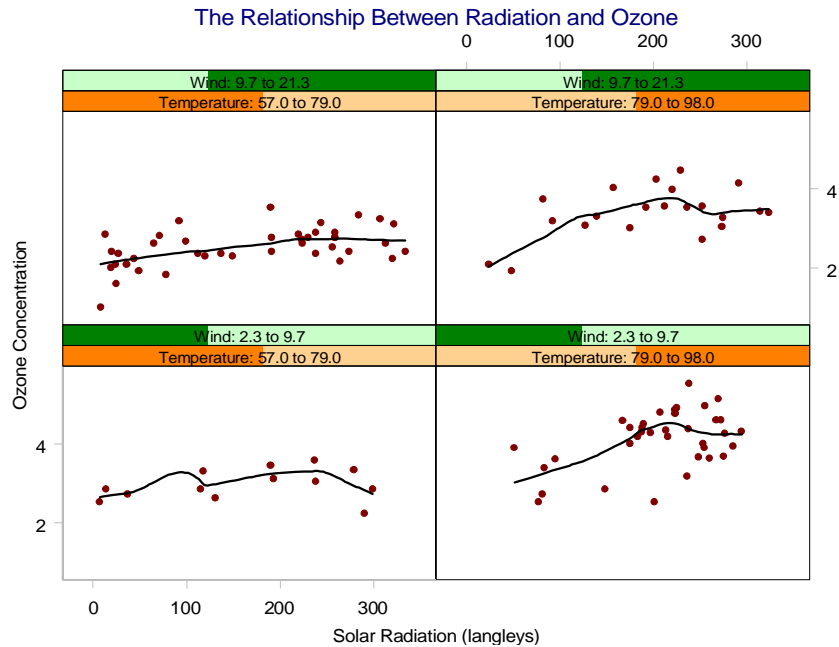



Figure 2.5: *Ozone concentration and solar radiation: This graph shows that radiation explains variation in ozone levels beyond that explained by wind speed and temperature.*

- Select the plot by clicking a line or symbol in any one of the panels.
- Open the **Plots 2D** palette and click the **Linear Fit** button . A linear regression line replaces the loess curve in each panel, as shown in Figure 2.6. This graph suggests that high temperatures with less wind result in the strongest dependence of ozone on radiation.

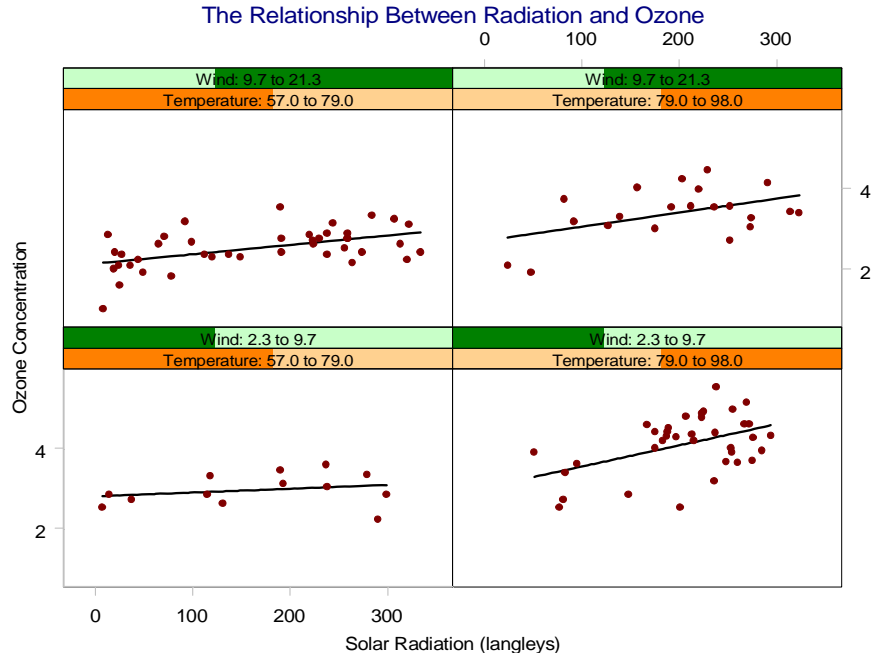




Figure 2.6: *A linear regression has replaced the loess curve in each panel.*

HIGHLIGHTING DATA POINTS

You can highlight data points in the graph and have the same points highlighted in the **Data** window, as well as in other graphs.


1. To open the **Graph Tools** palette, click the **Graph Tools** button  in the **Graph** toolbar.
2. Click the **Select Data Points** button .
3. Drag around a selection of points in the upper right panel of the graph.

Notice that the selected points are highlighted in both the graph and the **Data** window. If we had other **Graph Sheets** open based on these data, the points would also be highlighted in these other graphs.

4. Click an empty part of a panel to remove the selection.

EXTRACTING GRAPH PANELS

It is easy to “drill down” into a Trellis graph panel using buttons on the **Graph Tools** palette.

1. Click the **Extract Panel** button  on the **Graph Tools** palette.
2. Click the lower left panel of the Trellis graph. The panel is extracted and displayed as a full-sized graph, as shown in Figure 2.7.

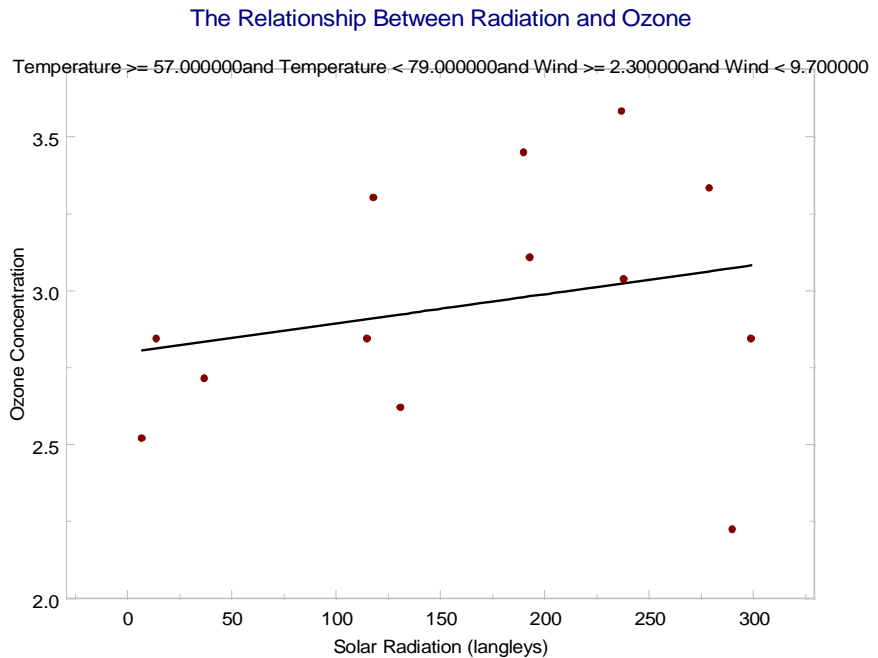



Figure 2.7: A panel extracted from a Trellis graph.

3. Click the **Show All Panels** button  to restore the Trellis graph.
4. From the main menu, select **File ► Save As**, and then navigate to your current project folder (typically **C:\Documents and Settings\username\My Documents\S-PLUS Projects\Project1**). Save the multipanel plot as **mpanel.sgr**.

5. Leave the `exenvirn` **Data** window open, but close the **Graph Sheet** and any open palettes.

Note

The data are not saved with the **Graph Sheet**. When the **Graph Sheet** is reopened, it redraws using the current data set named `exenvirn`. To embed the data within the **Graph Sheet** before saving, choose **Graph ► Embed Data** from the main menu. See the section Embedding and Extracting Data in Graph Sheets on page 45 for more details.

APPLYING STATISTICAL MODELS

S-PLUS provides a vast array of statistical techniques, with the most widely used techniques accessible through dialog boxes launched from the **Data** and **Statistics** menus.

All techniques available on the menus are also available through the S-PLUS language. Use commands either interactively in the **Commands** window, or as script in a **Script** window. In the course of an analysis, you may find it convenient to begin by fitting a model through a handy dialog box, and then proceed to analyze the model and perform diagnostics through the flexible and powerful S language.

In this section, fit linear regression models to predict ozone using temperature, radiation, and wind.

Summaries

Examine the simple summaries of the `exenvirn` data.

1. From the main menu, choose **Statistics ► Data Summaries ► Summary Statistics** to display the **Summary Statistics** dialog box.
2. In the **Data** group, `exenvirn` appears by default in the **Data Set** box.
3. Click **OK** to display summaries for the data columns in a **Report** window.
4. From the main menu, choose **Statistics ► Data Summaries ► Correlations** to display the **Correlations and Covariances** dialog box.
5. In the **Data** group, `exenvirn` appears by default in the **Data Set** box.
6. Click **OK**. The correlations for the data columns are added beneath the summaries in the **Report** window.
7. Close the **Report** window (do not save it).

Linear Models In this section, use the **Linear Regression** dialog box to fit a linear model predicting `Ozone` from the other variables.

**Simple Model
From a Dialog
Box**

1. In the **Data** window, select `Ozone`, `Radiation`, `Temperature`, and `Wind`, in that order, by dragging across the column headers.
2. From the main menu, choose **Statistics ► Regression ► Linear** to display the **Linear Regression** dialog box.
3. In the **Data** group, `exenvirn` appears by default in the **Data Set** box.
4. In the **Formula** box of the **Variables** group, examine the expression **Ozone ~ Radiation + Temperature + Wind**. Listed first is the *response* variable, `Ozone`. This response was chosen because `Ozone` was the first column you selected. The *predictor* variables, shown after the tilde (~), represent the other variables in the order in which they were selected.
5. Click the **Plot** tab to display the **Plot** page.
6. In the **Plots** group, select the **Residuals vs Fit** check box.
7. Click **OK**.

The regression results appear in the **Report** window. In addition, a new **Graph Sheet** displays the diagnostic plot.


Note

The data used in this plot are embedded within the **Graph Sheet**. Subsequent changes in the `exenvirn` data set will not affect these plots.

**The Formula
Builder**

Using the **Formula Builder**, you can describe complex regression models by selecting variables and indicating how they are used in the model. For example, you might want to add an interaction term to the model.

8. Close the **Graph Sheet** and the **Report** window and click the **Data** window, outside the selected data, to clear the selection.
9. From the main menu, choose **Statistics ► Regression ► Linear** to display the **Linear Regression** dialog box.

10. In the **Variables** group, from the dropdown list in the **Dependent** box, select **Ozone**.
11. Using CTRL-click, select **Radiation**, **Temperature**, and **Wind** from the dropdown list in the **Independent** box. Notice that the formula reflects your changes.
12. Click the **Create Formula** button to display the **Formula** dialog box.
13. In the **Variable** group, in the **Choose Variables** box, CTRL-click to select **Radiation** and **Temperature**.
14. In the **Add** group, click **Interaction** to include the interaction between radiation and temperature as a predictor.
15. Click **OK** to close the **Formula** dialog box. The formula you generated appears in the **Formula** box of the **Linear Regression** dialog box.
16. Click **OK** to generate the model.
17. Close the **Report** window.
18. From the main menu, choose **Statistics ► Regression ► Linear** to display the **Linear Regression** dialog box again.
19. Click the **Dialog Rollback** button  (located at the bottom center of the dialog box page, just to the right of the **Apply** button) to select the previous dialog box state. The previous values for **Data Set** and **Formula** are filled in.
20. Click the **Results** tab to display the **Results** page of the dialog box.
21. In the **Printed Results** group, select the **ANOVA Table** check box. This selection provides an analysis of variance table for the linear model.
22. Click **OK**. The ANOVA table for the fit appears in the **Report** window below the regression results.
23. When you finish examining the results, close the **Report** window and the `exenvirn` **Data** window.

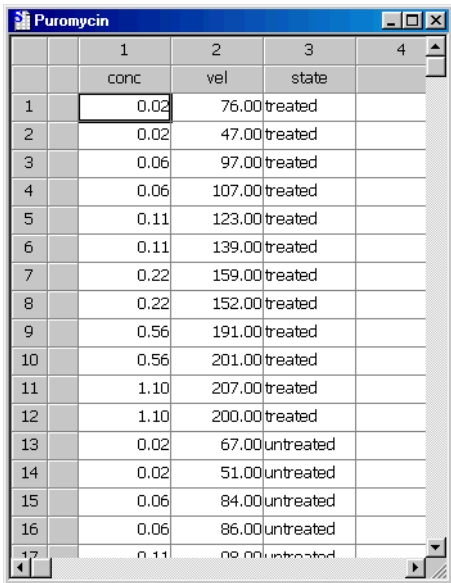
More Detailed Results

DOING MORE WITH GRAPHICS

Varying 2D Axes Types

By default, 2D plots are drawn on linear x and y axes. Sometimes it is useful to create plots using a logarithmic or probability scale on one or both axes. You can create such plots by selecting the 2D axis type from the toolbar *before* selecting the plot type.

1. From the main menu, choose **Data ► Select Data** to display the **Select Data** dialog box.
2. In the **Existing Data** group, type **Puromycin** in the **Name** box.
3. Click **OK** to load the data into a **Data** window.



	1	2	3	4
	conc	vel	state	
1	0.02	76.00	treated	
2	0.02	47.00	treated	
3	0.06	97.00	treated	
4	0.06	107.00	treated	
5	0.11	123.00	treated	
6	0.11	139.00	treated	
7	0.22	159.00	treated	
8	0.22	152.00	treated	
9	0.56	191.00	treated	
10	0.56	201.00	treated	
11	1.10	207.00	treated	
12	1.10	200.00	treated	
13	0.02	67.00	untreated	
14	0.02	51.00	untreated	
15	0.06	84.00	untreated	
16	0.06	86.00	untreated	
17	0.11	98.00	untreated	

Figure 2.8: *The Puromycin data.*

The Puromycin data set is from a biochemical experiment testing the drug Puromycin. The column `conc` gives the enzyme concentration of the substrate, and `vel` is the initial velocity of the reaction. The state variable indicates whether or not the cell has been treated with Puromycin.

4. Select the columns `conc`, `vel`, and `state` by dragging the mouse across the column headers.

- From the **Standard** toolbar, choose **Log X** from the **Default 2D Axes Type** dropdown list.

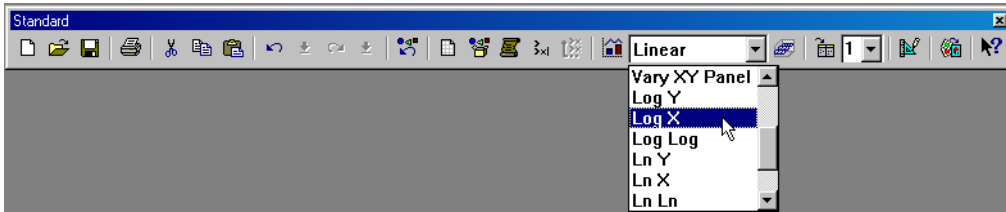



Figure 2.9: Changing the default 2D axes type.

- Open the **Plots 2D** palette and click the **Color** button . The treated and untreated cell observations appear in different colors.
- Make sure the graph is not selected, and then change the **Default 2D Axes Type** back to **Linear**.

Note

The **Default 2D Axes Type** control specifies the *default* axes type. In this example, if you do not change it back to **Linear**, subsequent plots will be created on a log scale as well. If your graph is selected when you change the default axes type, the axes type of your selected graph will also be changed.

- Close the **Graph Sheet**, the **Data** window, and the **Plots 2D** palette.

Creating Graphs With Multiple Axes

You can create plots showing different data series, with varying scales, against a single x or y variable. This is often useful in plotting revenue and profit (for example) against time. You can see at a glance whether revenue and profit are rising and falling together or if some more complicated relationship holds.

As a simple example, plot housing starts and manufacturing shipments on a time scale.

- From the main menu, choose **File ► Load Library** to display the **Load Library** dialog box, as shown in Figure 2.10.

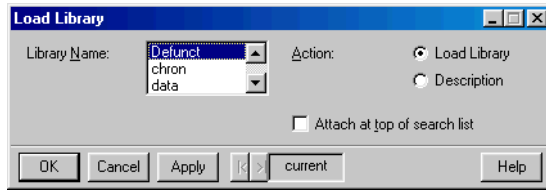



Figure 2.10: *The Load Library dialog box.*

2. In the **Library Name** box, select **example5** and click **OK** to load the library.

Open the sample data set `econ.df` by using the **Object Explorer**.

3. Click the **Object Explorer** button  on the **Standard** toolbar.
4. In the left pane of the **Object Explorer**, click the plus (+) sign to the left of the **SearchPath** icon.
5. Expand the **example5** folder by clicking the plus (+) sign to the left of its icon.
6. Select **econ.df** in the left pane to display its columns in the right pane. Notice that this sample data set contains two columns of class `ts` (years and `hstart`) and one column of class structure (`ship`).
7. In the left pane of the **Object Explorer**, double-click the icon to the left of `econ.df`.

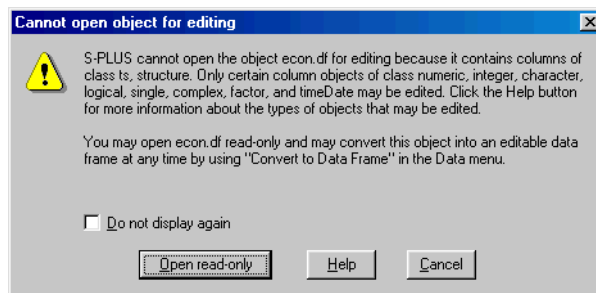



Figure 2.11: *Data objects containing columns of certain classes must be opened in read-only mode.*

8. Because econ.df contains columns of class `ts` and class `structure`, which are not supported in the **Data** window (see page 4), S-PLUS warns you that it will be opened in read-only mode. Click the **Open read-only** button to continue.

Hint

In read-only mode, columns in the **Data** window are slightly shaded.

9. With econ.df displayed in a read-only **Data** window, click the **Convert to Data Frame** button  on the **Data** window toolbar, as shown in Figure 2.12.

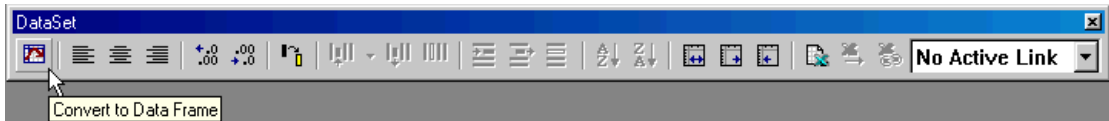


Figure 2.12: *The **Convert to Data Frame** button on the **Data** window toolbar.*

10. The **Convert Object to Data Frame** dialog box is displayed, as shown in Figure 2.13.

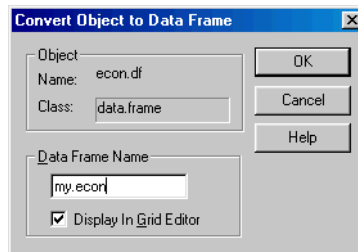


Figure 2.13: *The **Convert Object to Data Frame** dialog box.*

11. In the **Data Frame Name** text box, type **my.econ**.
12. Click **OK** to convert the data object and display it in a new **Data** window.

	1	2	3	4
	years	hstart	ship	
1	1966.00	81.90	NA	
2	1966.08	79.00	NA	
3	1966.17	122.40	NA	
4	1966.25	143.00	NA	
5	1966.33	133.90	NA	
6	1966.42	123.50	NA	
7	1966.50	100.00	NA	
8	1966.58	103.70	NA	
9	1966.67	91.90	NA	
10	1966.75	79.10	NA	
11	1966.83	75.10	NA	
12	1966.92	62.30	NA	
13	1967.00	61.70	42523.00	
14	1967.08	63.20	46029.00	
15	1967.17	92.90	47485.00	

Figure 2.14: *The converted my.econ data.*

13. In the my.econ **Data** window, select the columns years, hstart, and ship by dragging the mouse across the column headers.
14. From the main menu, choose **Graph ► 2D Plot** to display the **Insert Graph** dialog box.
15. Under **Axes Type**, select **Multiple Y**. Under **Plot Type**, select **Scatter Plot (x, y1, y2, ...)**. Accept the default **Graph Sheet**, GS1, and click **OK**.

A plot appears with hstart plotted along the left y axis, ship along the right y axis, both plotted against years along the x axis. You could also create this plot by selecting **Multiple Y** as the default axes type on the main toolbar, and then clicking the **Scatter** button on the 2D Plots palette.

16. From the main menu, choose **Insert ► Legend**. A legend appears, along with the **Legend** dialog box. Click **OK** to dismiss the dialog box and drag the legend to the upper left of the plot. The resulting graph is shown in Figure 2.15.

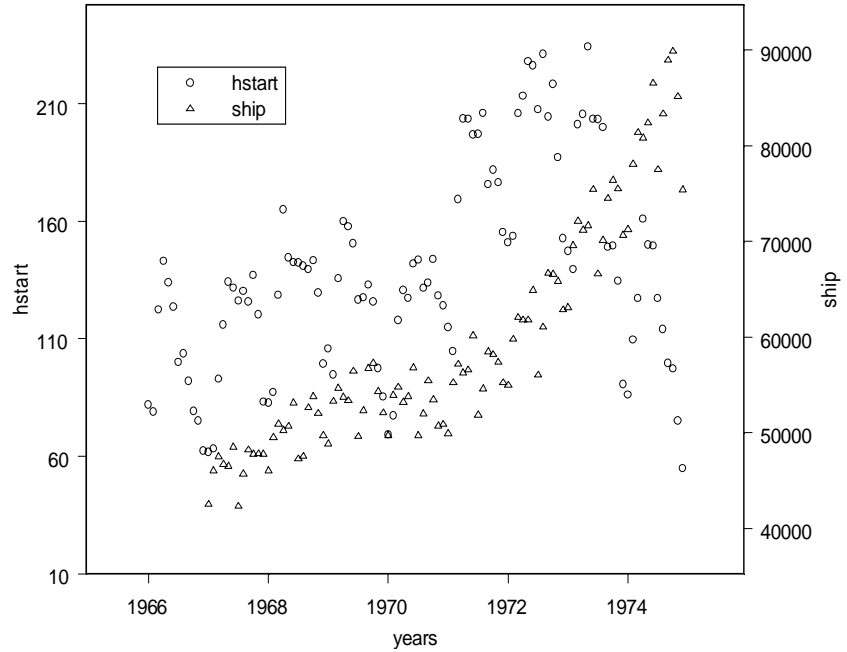


Figure 2.15: *A plot with multiple y axes.*

Another way to show data series with varying scales is to put the series in separate panels.

17. Select the rectangular plot area defined by the axes. Change the **Default 2D Axes Type** on the **Standard** toolbar to **Vary Y Panel**.

The graph is redrawn, placing each plot in a separate panel, as shown in Figure 2.16. The y axis is scaled separately in each panel.

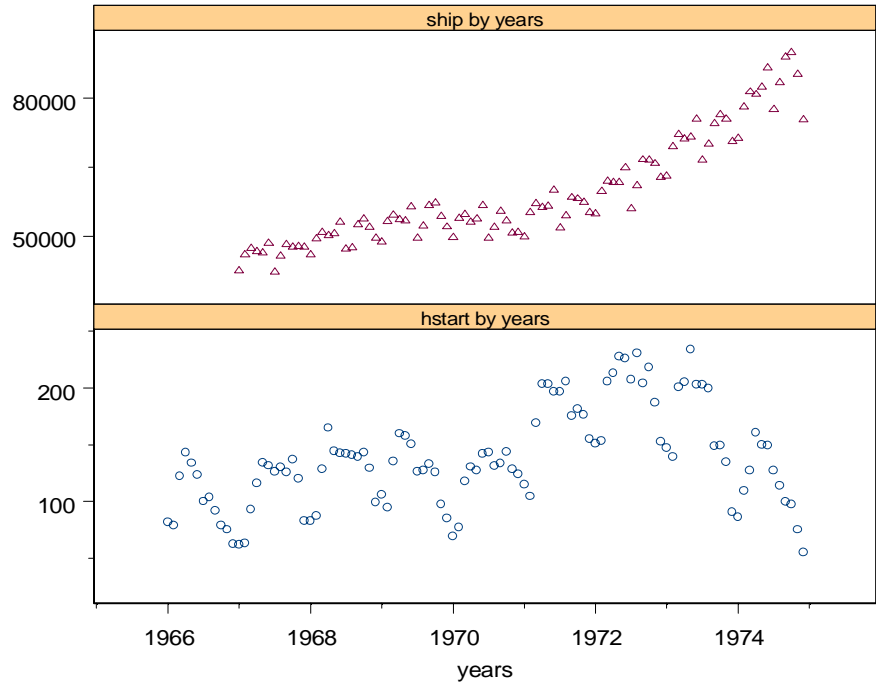


Figure 2.16: *Two data series with varying scales in separate panels.*

18. Make sure the plot is not selected, and then change the **Default 2D Axes Type** back to **Linear**. Close the **Data** windows.

EMBEDDING AND EXTRACTING DATA IN GRAPH SHEETS

You can store the data used to create any graph within the **Graph Sheet**. Using this feature, you can provide a fully editable graph to friends or colleagues without also having to provide a separate data file.

Embed the `my.econ` data in the **Graph Sheet**.

1. Make sure the **Graph Sheet** is in focus.
2. From the main menu, choose **Graph ► Embed Data**.

You can also extract the data embedded in any **Graph Sheet** for further analysis or manipulation.

Extract the `my.econ` data we just embedded in the **Graph Sheet**.

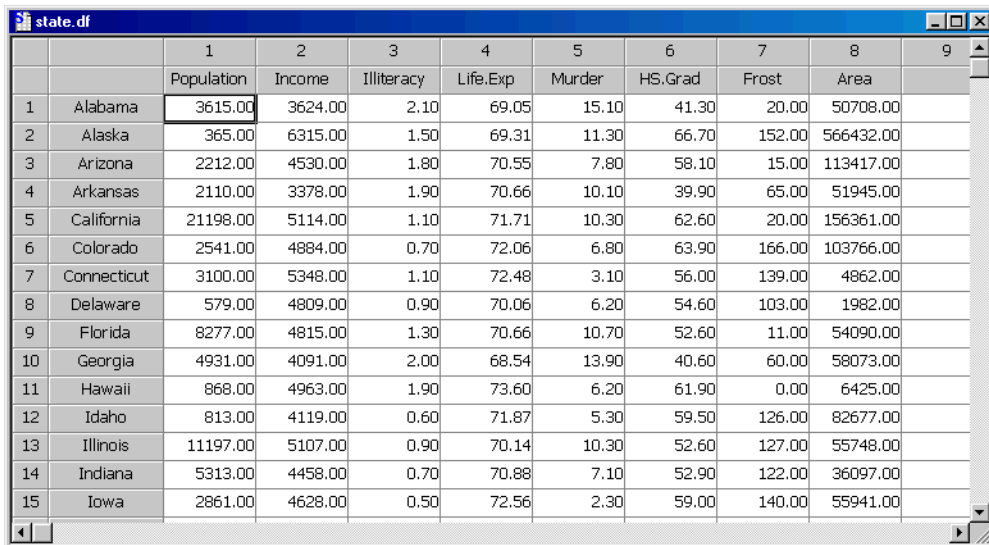
3. Make sure the **Graph Sheet** is in focus.
4. From the main menu, choose **Graph ► Extract Data** to display the **Extract Data** dialog box.
5. Specify a name (such as `my.econ2`) for the extracted data set and click **OK**.
6. Close the **Graph Sheet**, saving it as `econ.sgr`.

Before proceeding, close all open windows except the **Object Explorer**.

CREATING A GRAPH USING THE OBJECT EXPLORER

In addition to helping you organize your objects, the **Object Explorer** is a handy tool for manipulating them. It can be particularly useful when creating graphs from a data set with many columns.

1. With the **Object Explorer** in focus and the **example5** folder expanded in the left pane, double-click the icon to the left of the sample data set `state.df` to display the data in a **Data** window.




		1	2	3	4	5	6	7	8	9
		Population	Income	Illiteracy	Life.Exp	Murder	HS.Grad	Frost	Area	
1	Alabama	3615.00	3624.00	2.10	69.05	15.10	41.30	20.00	50708.00	
2	Alaska	365.00	6315.00	1.50	69.31	11.30	66.70	152.00	566432.00	
3	Arizona	2212.00	4530.00	1.80	70.55	7.80	58.10	15.00	113417.00	
4	Arkansas	2110.00	3378.00	1.90	70.66	10.10	39.90	65.00	51945.00	
5	California	21198.00	5114.00	1.10	71.71	10.30	62.60	20.00	156361.00	
6	Colorado	2541.00	4884.00	0.70	72.06	6.80	63.90	166.00	103766.00	
7	Connecticut	3100.00	5348.00	1.10	72.48	3.10	56.00	139.00	4862.00	
8	Delaware	579.00	4809.00	0.90	70.06	6.20	54.60	103.00	1982.00	
9	Florida	8277.00	4815.00	1.30	70.66	10.70	52.60	11.00	54090.00	
10	Georgia	4931.00	4091.00	2.00	68.54	13.90	40.60	60.00	58073.00	
11	Hawaii	868.00	4963.00	1.90	73.60	6.20	61.90	0.00	6425.00	
12	Idaho	813.00	4119.00	0.60	71.87	5.30	59.50	126.00	82677.00	
13	Illinois	11197.00	5107.00	0.90	70.14	10.30	52.60	127.00	55748.00	
14	Indiana	5313.00	4458.00	0.70	70.88	7.10	52.90	122.00	36097.00	
15	Iowa	2861.00	4628.00	0.50	72.56	2.30	59.00	140.00	55941.00	

Figure 2.17: *The state.df data.*

The `state.df` data set has columns showing information about states in the United States.

2. In the left pane of the **Object Explorer**, click the icon to the left of `state.df` to display its columns in the right pane.
3. Click the icon next to **Income**; then CTRL-click **Illiteracy** and then **Area**. Notice that these columns are now also selected in the **Data** window.

4. Close the **Data** window; in this exercise, you use the **Object Explorer** for graphing.
5. Open the **2D Plots** palette and click the **Loess** button .

Two loess plots are created in a **Graph Sheet**, both scaled to the same set of axes.



Editing a Plot in the Object Explorer

Using the **Object Explorer** and properties dialog boxes, you can edit any open **Graph Sheet**. As an example, change the format of the x axis labels.

6. With the **Object Explorer** in focus, expand the **Graphs** folder in the left pane.
7. Expand **GS1** (or the graph sheet name that corresponds to the plot you just created).
8. Expand **Graph2D** and then click **Axis2dX1**, both in the left pane.
9. In the right pane of the **Object Explorer**, double-click **Axis2DLabelX** to open the **X Axis Labels** properties dialog box.
10. In the **Label 1** group, change the **Type** box from **Auto** to **Decimal** and make sure **Precision** is set **1**.
11. Click **OK**.

Viewing Plots in Separate Panels


Relationships between variables can be seen much more clearly if they are scaled to different y axes. One way to do this is to view the plots in separate panels, keeping the x -axis scaling the same.

12. Click a blank spot anywhere inside the axes region to select the graph.
13. Click the **Graph Tools** button  on the **Graph** toolbar.
14. On the **Graph Tools** palette, click the **Separate Panels with Varying Y Axes** button .

The plots now appear in two panels, stacked one over the other.

Removing Outliers

Notice that there is one data point far from the others. If you place your cursor at that point, you see that it represents Alaska. Remove this outlier from the plots.

15. Click the **Select Data Points** button  on the **Graph Tools** palette.
16. In either panel, drag a rectangle around the point representing Alaska to select it.
17. From the main menu, choose **Format ► Exclude Selected Points**.

The loess smoothing is recalculated, and the points representing Alaska are removed from the plots, as shown in Figure 2.18.

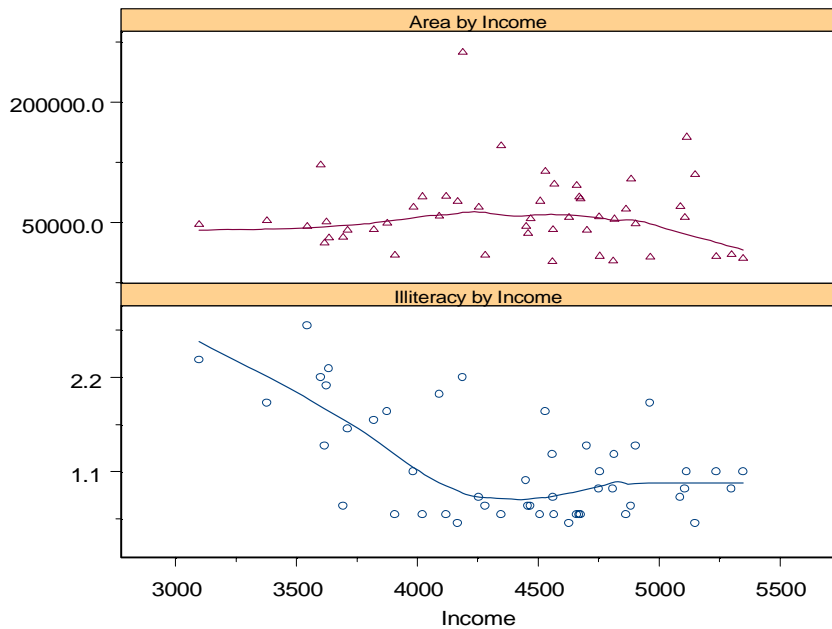


Figure 2.18: *Separate panel plot with outlier excluded.*

18. Click the **Select Tool** button  to return to the selection cursor.
19. Close all open windows and palettes.



CREATING A 3D GRAPH

In this exercise, use the data set `exsurf` to create a 3D plot.

1. From the main menu, choose **Data ► Select Data** to display the **Select Data** dialog box.
2. In the **Existing Data** group, type `exsurf` in the **Name** box.
3. Click **OK** to load the data into a **Data** window.

	1	2	3	4
	V1	V2	V3	
1	-2.00	-2.00	1.28	
2	-1.87	-2.00	1.63	
3	-1.74	-2.00	1.94	
4	-1.61	-2.00	2.15	
5	-1.48	-2.00	2.22	
6	-1.35	-2.00	2.17	
7	-1.22	-2.00	2.03	
8	-1.09	-2.00	1.88	
9	-0.96	-2.00	1.76	
10	-0.83	-2.00	1.74	
11	-0.70	-2.00	1.84	
12	-0.57	-2.00	2.07	
13	-0.44	-2.00	2.36	
14	-0.31	-2.00	2.68	
15	-0.18	-2.00	2.93	
16	-0.05	-2.00	3.07	
17	0.08	-2.00	3.07	

Figure 2.19: *The exsurf data.*

4. Now select the columns V1, V2, and V3 by dragging the mouse across the column headers.
5. Click the **3D Plots** button  on the **Standard** toolbar to open the **Plots 3D** palette.
6. Click the **Spline Surface** button  on the **Plots 3D** palette. The resulting graph is shown in Figure 2.20.

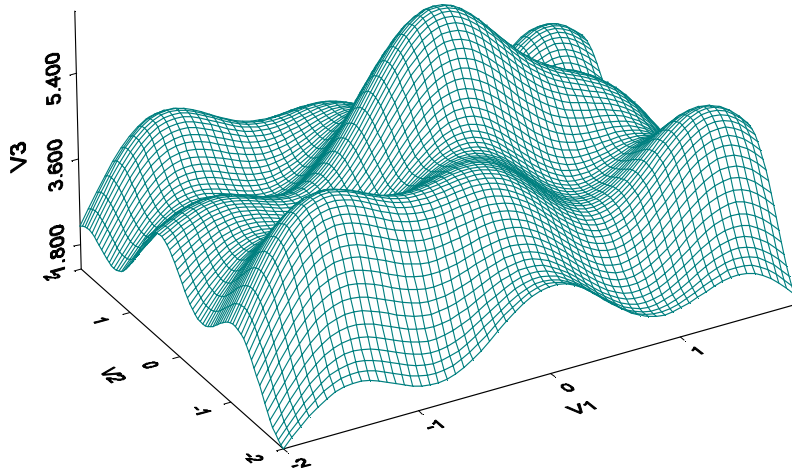



Figure 2.20: 3D spline plot of the *exsurf* data.

Adding Color Draping

In this section, add color draping to the spline plot.

7. Click the maximize button in the upper right corner of the **Graph Sheet**.
8. Click the mesh of the surface plot to select it.
9. Click the **32 Color Surface** button  on the **Plots 3D** palette. The graph redraws with the new format, as shown in Figure 2.21.

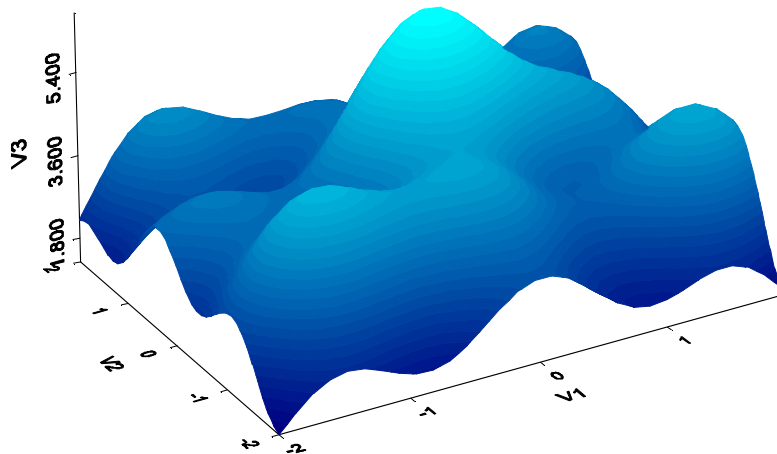


Figure 2.21: Color draping can be done with up to 64 colors.

10. Close all open windows and palettes.

CREATING POWERPOINT SLIDES

If you have PowerPoint installed on your computer, you can automatically create a PowerPoint presentation from your S-PLUS graphs.

Use the graphs you saved during this tutorial to create a PowerPoint presentation.

1. Click the **PowerPoint Presentation** button  on the **Standard** toolbar.

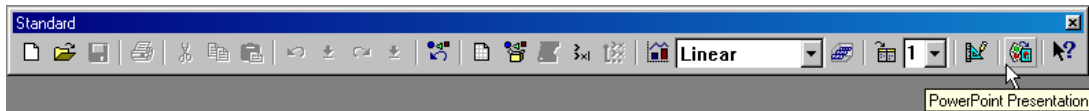


Figure 2.22: *The PowerPoint Presentation button on the Standard toolbar.*

The **Welcome** screen of the **PowerPoint Wizard** is displayed.

2. Click **Next**.
3. Click **Add Graph** to locate your graphs (**mpanel.sgr** and **econ.sgr**) and then add them to the list for your presentation.
4. Click **Next** to move to the next page of the wizard.
5. Click **Finish**.

PowerPoint opens and the graphs are inserted as slides in a new PowerPoint presentation. Note that the graphs are inserted in the order you specified in the wizard's presentation list.

USING S-PLUS WITH MICROSOFT EXCEL

In addition to being able to exchange data with Microsoft Excel, you can also open Excel worksheets from directly within S-PLUS, making your Excel data instantly available for creating graphics and performing statistical analyses.

Create a data set representing a sinusoidal function in an Excel worksheet, and then plot it and test for serial correlation using S-PLUS.

Creating Excel Data Inside S-PLUS

Create the data set in an Excel worksheet within S-PLUS.

1. From the main menu, choose **File ► New** to open the **New** dialog box.
2. Select **Microsoft Excel Worksheet** and click **OK**.

An Excel worksheet entitled **SplusBook1** appears, as shown in Figure 2.23.

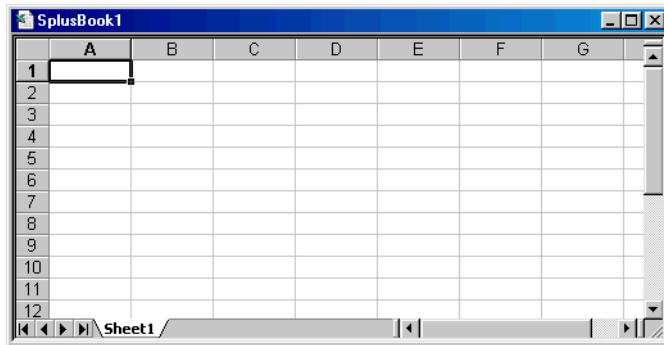


Figure 2.23: *An Excel worksheet created from within S-PLUS.*

3. In cell C5, type the number **1** and press ENTER.
4. Select cell C6.
5. On the **Formula** toolbar, click the **Edit Formula** button (marked by an equals sign). An equals sign appears in the **Formula** text box.
6. In the **Formula** text box, immediately after the equals sign, type **C5+1** and press ENTER.

The number 2 appears in cell C6, and cell C7 is highlighted.

7. Select cell C6 and press CTRL-C.
8. Select cells C7 through C34 and then press CTRL-V.

Column C, rows 5 through 34, should now contain the values from 1 through 30.

9. Select cell D5.
10. On the **Formula** toolbar, click the **Edit Formula** button.
11. In the **Formula** text box, immediately after the equals sign, type $3*\text{SIN}(C5)^2$ and press ENTER.



The number 2.12422 appears in cell D5, and cell D6 is highlighted.

12. Select cell D5 and press CTRL-C.
13. Select cells D6 through D34 and then press CTRL-V.

Column D, rows 6 through 34, should fill with values between 0 and 3, inclusive.

Plotting Excel Data

Create an S-PLUS graph from our data.

14. Select cells C5 through D34.
15. On the **Standard** toolbar, click the **2D Plots** button  to open the **Plots 2D** palette.
16. Click the **Line** button  to create a line plot of the data.

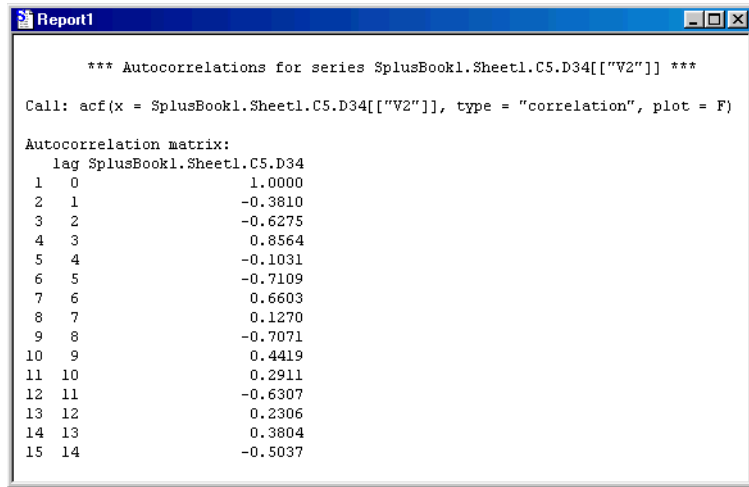
Behind the scenes, a *link* has been created between Excel and S-PLUS.

Analyzing Excel Data

Use the autogenerated link between Excel and S-PLUS that was just created to compute the autocorrelation function on our Excel data.

17. From the main menu, choose **Statistics ► Time Series ► Autocorrelations** to open the **Autocorrelations and Autocovariances** dialog box.
18. In the **Object** dropdown list of the **Data** group, select **SplusBook1.Sheet1.C5.D34**, which is the link object.
19. In the **Variable** dropdown list, select **V2** and then click **OK**.

A **Report** window displays the autocorrelation matrix, and a plot is created showing that significant serial correlation appears in the series, as we would expect. See Figure 2.24.



Series : SplusBook1.Sheet1.C5.D34[["V2"]]

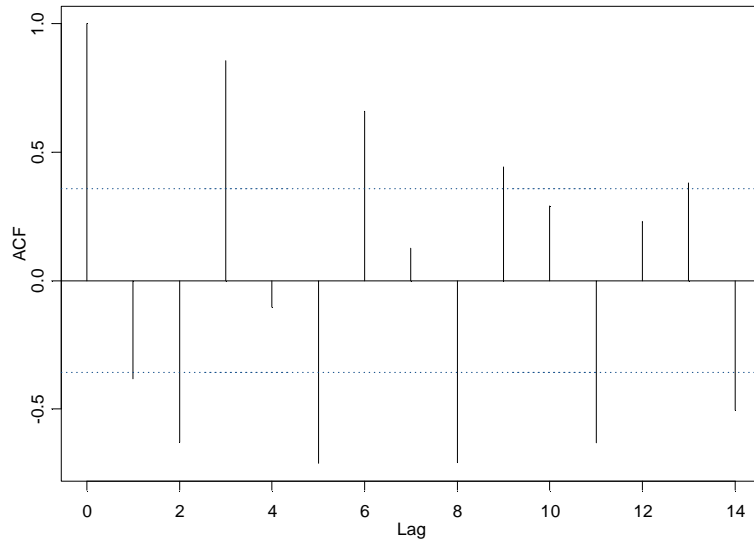


Figure 2.24: *The autocorrelation matrix and plot for our Excel data.*

As our plot example shows, S-PLUS automatically creates a link whenever you select a region of an Excel worksheet and attempt to create a plot. Similarly, it automatically creates a link if you select some data and try to perform a statistical analysis.

For most purposes, these automatically created links are all you need. However, you can have more control over the link if you create it with the Link Wizard. Use the Link Wizard if you need to specify row and column names for the data you select or if you want to modify the data formats S-PLUS uses to display the linked data. For detailed information on using the Link Wizard, see Chapter 10, Using S-PLUS with Other Applications, in the *User's Guide*.

USING THE S-PLUS LANGUAGE

For some analyses, it is more convenient to work with an interactive data analysis language than to maneuver through a series of dialog boxes. The **Commands** window provides that interactive access to the S-PLUS language.

In this section, use the **Commands** window to fit another linear model and perform some diagnostics.


1. Close all open windows.
2. Open the **Commands** window by clicking the **Commands Window** button  on the **Standard** toolbar.



Figure 2.25: *The **Commands** window button on the **Standard** toolbar.*

S-PLUS Language Basics

Everything you type in S-PLUS is an *expression*, and expressions are evaluated when you press the ENTER key. Most S-PLUS expressions are *function calls* since S-PLUS is a functional language. To call a function, simply type the name of the function followed by any arguments to the function enclosed in a set of parentheses. Remember that S-PLUS commands are case-sensitive.

The **Commands** window uses a `>` prompt. If you press ENTER after an expression that is syntactically incomplete, it is not evaluated immediately. Instead, S-PLUS prompts you to continue the expression with the `+` continuation prompt.

You can type several expressions on the same line by separating them with semicolons (`;`). S-PLUS evaluates each in succession when you press ENTER. A semicolon is not required at the end of each line, only between multiple expressions on a single line.

You can include comments in S-PLUS expressions by inserting them after a `#` symbol. Anything after the `#` on a line is interpreted as a comment and is not evaluated.

The result of any S-PLUS expression is an *object* that you can save by assigning it a name using the assignment operator `<-`. Each data set used in S-PLUS is represented as an S-PLUS data object of a certain *class*.

Note

The assignment operator is typed by typing a “less than” character (`<`) followed immediately by a hyphen (`-`). Be careful not to put any spaces between these two characters.

S-PLUS ignores most spaces, so you can include or omit spaces in typing your expressions as you prefer. However, do not place extra spaces in the name of an object, between the digits of a single number, or between the `<` and `-` in the assignment operator.

In the following examples, text appearing after the `>` symbol is to be typed at this prompt. Do not type the `>` or the first `+` at the beginning of a line.

Listing Objects

In this section, replicate the regression results obtained earlier using the `exenvirn` data and store them in an object named `fit.lm`.

- At the prompt in the **Commands** window, type the following (remember that the S-PLUS language is case-sensitive):

```
> fit.lm <- lm(Ozone~Radiation+Temperature+Wind,
+ data=exenvirn)
```

- Now, to see a brief summary for the model, type

```
> fit.lm
```

to display a brief summary for the model:

Call:

```
lm(formula = Ozone ~ Radiation + Temperature + Wind,
data = exenvirn)
```

Coefficients:

```
(Intercept)  Radiation  Temperature      Wind
-0.2973296  0.00220541  0.05004432 -0.07602195
```

```
Degrees of freedom: 111 total; 107 residual  
Residual standard error: 0.5101592
```

You can extract the specific model components of fitted values, coefficients, and residuals using the specific extraction functions `fitted`, `resid`, and `coef`. For example, to extract the coefficients from `fit.lm`, use `coef` as follows:

```
> b <- coef(fit.lm)  
> b[2]  
Radiation  
0.002205541
```

Fitting a Linear Model

When fitting the model using dialog boxes, you added one interaction term to examine the interaction between temperature and radiation in determining ozone level. Now fit a model containing interactions and explore whether the interactions are significant.

5. To fit a linear model with all two-way interactions, type

```
> fit.int <- lm(Ozone~(Radiation+Temperature+Wind)^2,  
+ data=exenvirn)
```

6. For a brief summary of the fit, type

```
> fit.int
```

7. For a detailed summary, type

```
> summary(fit.int)
```

8. For an F-test comparing this model to the model fit above, type

```
> anova(fit.lm, fit.int)
```

Running an S-PLUS Script


The **Script** window makes it easy to edit and run several lines of commands. You can copy and paste expressions from the **Commands** window into a **Script** window, and then save the script as an external (`.ssc`) file.

Create and run a new S-PLUS language script. Start by copying and pasting the two expressions we typed in the **Commands** window.

9. From the main menu, choose **File ► New**.

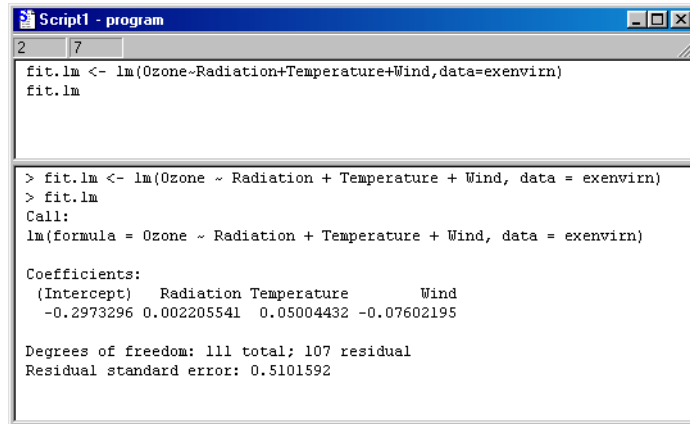
10. Select **Script File** and click **OK**.
11. Click the title bar of the **Commands** window to make it the active window.
12. Copy and paste the following two lines from the **Commands** window into the new **Script** window, being careful to exclude the > prompt as you highlight each line:

```
fit.lm <- lm(Ozone~Radiation+Temperature+Wind,data=exenvirn)
fit.lm
```

13. Click the **Run** button  on the **Script** window toolbar.



The script output appears in the lower pane, as shown in Figure 2.26.



```
Script1 - program
2 | 7
fit.lm <- lm(Ozone~Radiation+Temperature+Wind,data=exenvirn)
fit.lm



> fit.lm <- lm(Ozone ~ Radiation + Temperature + Wind, data = exenvirn)
> fit.lm
Call:
lm(formula = Ozone ~ Radiation + Temperature + Wind, data = exenvirn)

Coefficients:
(Intercept)  Radiation  Temperature    Wind
-0.2973296  0.002205541  0.05004432 -0.07602195

Degrees of freedom: 111 total; 107 residual
Residual standard error: 0.5101592
```

Figure 2.26: Output displayed in the lower pane of the **Script** window.

14. Close the **Commands** and **Script** windows (do not save script).

Notice that there is no prompt in the **Script** window. To run a script, simply click the **Run** button  on the **Script** window toolbar or press F10. To run only selected commands, first highlight them, and then click the **Run** button  or press F10. (If no output appears in the lower pane, choose **Options** ► **Text Output Routing** and select **Script Output** in both columns.)

GETTING HELP IN S-PLUS

HTML Help

Online help is available for both the S-PLUS graphical user interface and the S-PLUS programming language. From the main menu:

- Choose **Help ► Available Help ► S-PLUS Help** to access the online help for the graphical user interface.
- Choose **Help ► Available Help ► Language Reference** to access the online help for the S-PLUS programming language.

Online help in S-PLUS is based on Microsoft Internet Explorer and uses an HTML window to display the help files.

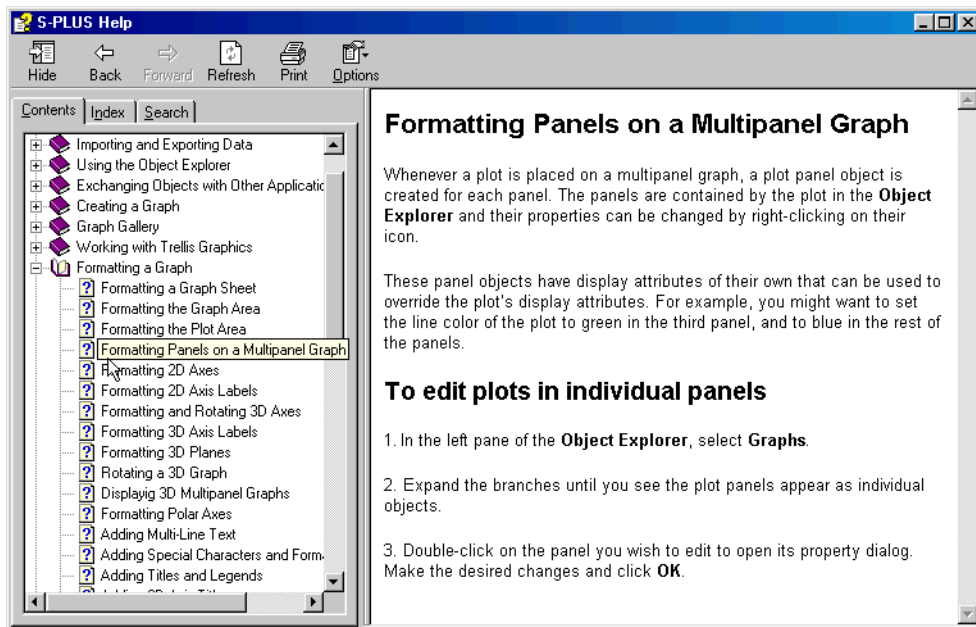


Figure 2.27: The S-PLUS Help window.

As shown in Figure 2.27, the HTML Help window has three main areas: the *toolbar*, the *left pane*, and the *right pane*.

Using the Toolbar Table 2.1 lists the four main buttons on the help window toolbar (in some cases, you might see more).

Table 2.1: *Help window toolbar buttons.*

Button Name	Description
Hide (or Show)	If the button is labeled Hide , it hides the left pane. If the button is labeled Show , it shows the left pane.
Back	Returns to previously viewed help topic.
Forward	Moves to next help topic.
Print	Prints the current help topic.

Using the Left Pane

The left pane contains three tabs: the **Contents** tab, the **Index** tab, and the **Search** tab:

- The **Contents** tab organizes help topics by category so that related help files can be found easily. These categories appear as small book icons, labeled with the name of the category. To open a category, double-click the icon or label. To select a topic within the category, double-click its question-mark icon or the topic title.
- The **Index** tab lists available help topics by keyword. Keywords are typically function names for S-PLUS language functions and topic names for graphical user interface topics. Simply type in a keyword and HTML Help will find the keyword that most closely matches it. Click **Display** (or double-click the selected title) to display the help topic.
- The **Search** tab provides a full-text search for the entire help system. Simply type in a keyword, and all the help files containing that keyword are listed in a list box. Select the desired topic and click **Display** (or double-click the selected title) to display the help topic.

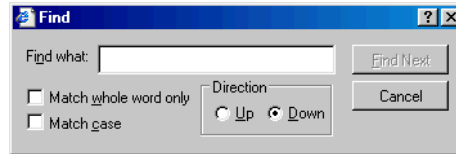
Using the Right Pane

The right pane contains the help topic. It usually appears with both vertical and horizontal scroll bars, but you can expand the HTML Help window to increase the width of the right pane. Many help files

are too long to be fully displayed in a single screen, so choose a convenient height for your HTML Help window and then use the vertical scroll bars to scroll through the text.

The right pane contains a search-in-topic feature. To use it:

1. Type CTRL-F to open the **Find** dialog box (this dialog box is a feature of HTML Help inherited from Internet Explorer).



2. Type your search string in the **Find what** box.
3. Click **Find Next**.

Help in the Commands and Script Windows

When you work in the **Commands** window, you can get help for any command by using the ? or help function. For example, to open the help file for anova, simply type:

```
> help(anova)
```

or

```
> ?anova
```

To get help for a command when you are working in a **Script** window, highlight the command and press F1.

SUMMARY OF BASIC PROCEDURES

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USING MENUS

Main Menu

S-PLUS menus change, depending upon the type of window currently in focus. For example, if the active window (the highlighted window) is a **Data** window, the menu display options useful for operating on **Data** windows; some **Graph Sheet** and programming options are absent or dimmed.

Menu options ending with a ► symbol display a submenu when selected. Menu options ending with an ellipsis (...) display a dialog box when selected. To cancel a menu, simply click outside the menu or press ESC.

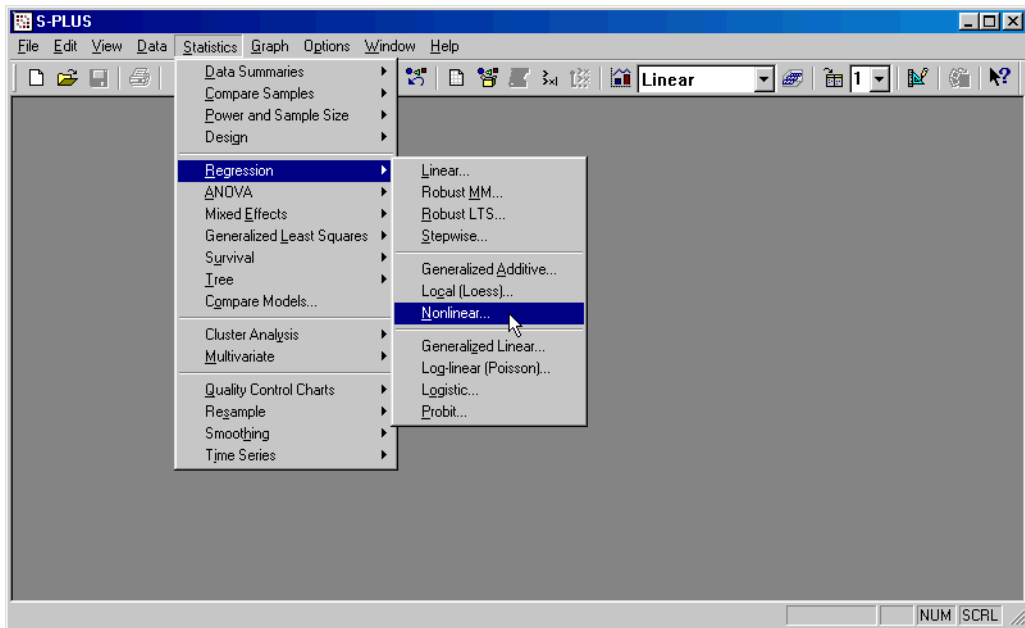


Figure 3.1: Choosing *Nonlinear Regression* from the *Statistics* menu.

Shortcut (Right-Click) Menus

When you click the right mouse button, a shortcut menu for the selected object is displayed. Shortcut menus contain options specific to the selected object and appear to the right or left of the mouse pointer. To close a shortcut menu without selecting an option, simply click outside the menu or press ESC.

USING DIALOG BOXES

Sometimes when you choose a menu option or click the mouse, S-PLUS displays a dialog box. You can use dialog boxes to specify information about a particular action.

There are two types of dialog boxes in S-PLUS: action dialog boxes and properties dialog boxes. Action dialog boxes carry out commands, such as copying a column. Properties dialog boxes display, and allow you to modify, the properties or characteristics of the selected object.

Dialog boxes can contain multiple tabbed pages containing different options. To access a particular page, click on its tab, or press CTRL-TAB, to move from page to page. When you click **OK** or **Apply** (or press ENTER), any changes you made on any of the tabbed pages are applied to the selected object.

Most of the dialog boxes in S-PLUS are *modeless*: They can be moved around on the screen, and they remain open until you choose to close them. This means you can make changes in a dialog box and see the effect without closing the dialog box using the **Apply** button. This feature is useful when you experiment with changes to an object and want to see the effect of each change.

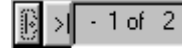
The Apply Button

Modeless dialog boxes have an **Apply** button. The **Apply** button acts much like the **OK** button, except that it does not close the dialog box. By specifying changes in a dialog box and clicking **Apply** (or pressing CTRL-ENTER), you can see the effect of your changes while keeping the dialog box open, so that you can make additional changes without having to reselect the dialog box.

If no changes have been made using the dialog box since it was last opened or “applied,” the **Apply** button is dimmed. To close the dialog box, click the **Cancel** button or the close button in the upper right corner of the dialog box.

The Dialog Rollback Buttons

Each time you make changes to a dialog box and click **OK** or **Apply**, S-PLUS remembers the changes and keeps track of the final “state” of the dialog box. The **Dialog Rollback** buttons, located at the bottom center of the dialog box, let you restore a dialog box to a prior state.



You can use the buttons to scroll back through each of the prior states of a dialog box until you find the set of values you want. By clicking **OK** or **Apply**, you can restore an object to a previous state. Alternatively, you can save time by using a prior state as a starting point for further changes.

Note that **Dialog Rollback** is different from **Undo** in that rollback can be applied selectively to individual objects.

Typing and Editing in Dialog Boxes

Table 3.1 below lists the shortcut keys you can use in dialog boxes for performing the associated tasks.

Table 3.1: *Shortcut keys when using dialog boxes.*

Action	Shortcut Key
Move to the next option in the dialog box.	TAB
Move to the previous option in the dialog box.	SHIFT-TAB
Move between pages in a multipage dialog box.	CTRL-TAB
Move to a specific option and select it.	ALT- <i>underlined letter</i> in the option name (Press again to move to the next option with the same underlined letter.)
Display a dropdown list.	ALT-down arrow

Table 3.1: *Shortcut keys when using dialog boxes. (Continued)*

Action	Shortcut Key
Select an item from a list.	Up or down arrow to move, ALT-down arrow to close the list
Close a list without selecting any items.	ALT-down arrow

USING TOOLBARS AND PALETTES

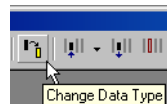
In addition to the **Standard** toolbar, which is always displayed, S-PLUS displays a special toolbar, depending upon the type of window that is currently open and active. For example, when a **Data** window is the active window, S-PLUS opens the **Data** window toolbar; when a **Graph Sheet** is in focus, the **Graph** toolbar is displayed. Toolbar buttons provide convenient shortcuts to a number of menu selections. Note that you cannot turn off the display of the **Standard** and special toolbars.

When you position the mouse pointer over a toolbar button, a description appears in the status bar at the bottom of the screen. Like menu options, some toolbar buttons may not be available at all times. Inactive toolbar buttons are dimmed; for example, the **Undo** button is dimmed if there is nothing to undo.

In addition to toolbars, several buttons display a palette of options when selected. For example, the **2D Plots** button displays a palette of 2D plot types. Tool palettes remain in view until you click the toolbar button again or click the palette's close box. Leaving a tool palette in view is convenient when you experiment with different options.

ToolTips

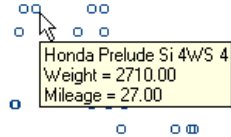
When you hover the mouse over a toolbar or palette button, helpful ToolTips appear:



To turn off this feature, choose **Options ► General Settings** from the main menu and clear the **Enable ToolTips** check box on the **General** page of the dialog box.

DataTips

DataTips are much like ToolTips except that they display information about data in the active **Data** window or **Graph Sheet**. For example, when you pause your mouse over a point in a scatter plot, or over the column number in a **Data** window, a DataTip displays information relevant to that point:



To turn off this feature, choose **Options ► General Settings** from the main menu and clear the **Enable DataTips** check box on the **Data** page of the dialog box.


SELECTING DATA

You can select data using either the **Select Data** dialog box or the **Object Explorer**. If you want to open the data in a **Data** window so that the data are visible as you work, the **Select Data** dialog box is simplest and fastest. If you want to work with many separate data objects with which you are already somewhat familiar, the **Object Explorer** can be much more efficient.

Using the Select Data Dialog Box

From the main menu, choose **Data ► Select Data** to display the **Select Data** dialog box. In the **Source** group, **Existing Data** is selected by default. In the **Existing Data** group, type a data object name or select a data object from the dropdown menu in the **Name** box. Click **OK** to load the data into a **Data** window.

Using the Object Explorer

Click the **Object Explorer** button  on the **Standard** toolbar. To select a data object, simply click its name in either pane of the **Object Explorer**. To display the data in a **Data** window, double-click the icon to the left of the data object's name.

IMPORTING DATA

You can import data from a file, from the leading financial databases Bloomberg, FAME, and MIM, or via an ODBC connection. ODBC connections allow you to extract data sets from enterprise databases. In all cases, there are numerous options you can specify.

For the simplest case in which you want to read an entire data file, choose **File ► Import Data ► From File** from the main menu. In the **Import From File** dialog box, navigate to the appropriate folder and select the desired file. Click **OK**.

For detailed information on how to import data from a financial database or via an ODBC connection, consult the *User's Guide* and the online help.

SELECTING VARIABLES TO PLOT

You create a plot by selecting variables from a given data set and then choosing a plot type, either by clicking a plot palette button or by selecting the plot type in the **Insert Graph** dialog box. You can select your variables in either a **Data** window or the **Object Explorer**.

Selecting Variables in a Data Window

- To select two or more contiguous variables, click and drag the mouse across the column headers.
- To select a range of variables, click the column header of the first variable, and then SHIFT-click the column header of the last variable in the range. All the variables between the variable in which you first click and the variable in which you SHIFT-click are selected.
- To select noncontiguous variables, or to select variables in a particular order, click the column header of the first variable, and then CTRL-click the column headers of the other desired variables.

Selecting Variables in the Object Explorer

- To select a range of variables, click one variable name, and then SHIFT-click another. All the variables between the variable you first click and the variable you SHIFT-click are selected.
- To select noncontiguous variables, click one variable name, and then CTRL-click one or more other variable names.

CREATING PLOTS

After you select the variables to plot, click a plot palette button, or select the plot type by choosing **Graph** from the main menu.

For your reference, Table 3.2 below shows the plot types most commonly associated with a given number of selected variables.

Table 3.2: *Common plots associated with a given number of variables.*

Number of Selected Variables	Plots
1	Box, QQ normal with line, probability, probability normal with line, histogram, density, histogram density, pie, dot, bar.
2	QQ, probability, Pareto, scatter, line, line with scatter, line with isolated points, step, high density, curve fit (linear, polynomial, exponential, power, log 10, natural log), nonlinear curve fit, smoothing (loess, spline, robust LTS, robust MM, kernel, Friedman), Y series, grouped box, polar.
3	Text as symbols, grouped bar with error, 3D scatter, 3D line, 3D line with scatter, 3D scatter with dropline, 3D regression, 3D regression with scatter, bubble, color, error bar, scatterplot matrix, contour (line or filled), 3D contour (line or filled), levels, 3D surface, 3D bar, comment, Smith.
4 or more	XY pairs, grouped bar, stacked bar, bubble color, high-low-close, high-low-open-close, candlestick, error bar-both, vector, area, Smith.

SELECTING GRAPH OBJECTS

To edit graphics, first select the object to edit. In S-PLUS, we distinguish between the **Graph Sheet**, the *graph area*, and the *plot area*, as illustrated in Figure 3.2.

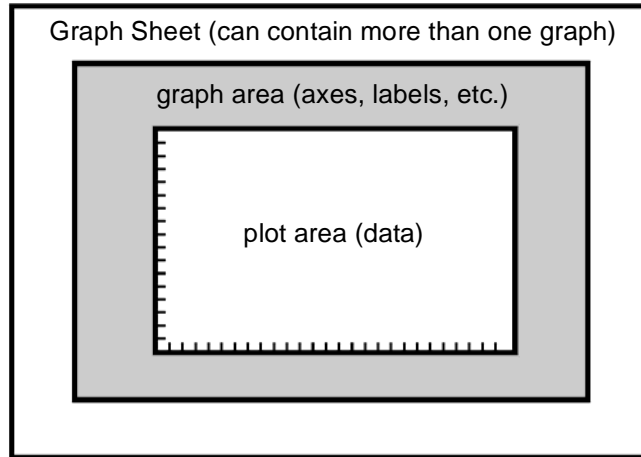


Figure 3.2: A *Graph Sheet* depicting the *graph area* (gray) and *plot area* (center white).

- The **Graph Sheet** can best be thought of as the sheet of paper on which you draw your plots. It can contain one or more graphs. When you print, you print one or more pages of a **Graph Sheet**.
- The graph area refers to the rectangle surrounding the data points, axes, legends, titles, and so on.
- The plot area is the rectangular area within the graph area where the data are actually plotted.

Within the plot area, you can select the plot area, the plot itself, or any plotted element:

- To select the plot, click any plotted element (line, symbol, filled region, etc.).
- To select the plot area, click a blank area within the plot area.

Figure 3.3 shows the difference in how S-PLUS displays the two selections.

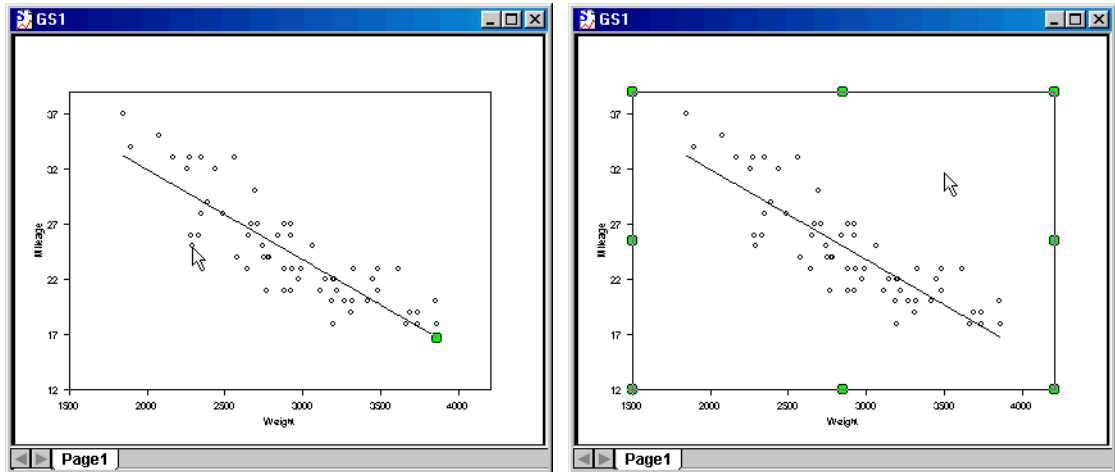


Figure 3.3: *Selecting the plot versus selecting the plot area.*

To select a plot element, such as an axis, axis title, or axis label, simply click it.

Axes and axis titles are editable and selectable separately on 2D graphs. Axis labels are formatted per axis.

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