CHAPTER

5

Exploring Data with
Visualization Techniques

Introduction

Once you have loaded and perhaps color coded your data, it is time to explore and visualize the data. SAS/SPECTRAVIEW provides several interactive visualization techniques to search through your loaded data and display an image. The techniques include:

point cloud
    to display response values as colored markers, showing individual data points.

cutting planes
    to produce slices of data, either perpendicular to an axis or not perpendicular to any axis. In addition to the axis cutting planes, you can request two- and three-dimensional surface views (surfaces, charts, stacks, and plots) at a specific cutting plane's location.

isosurface
    to produce a three-dimensional surface by connecting all the data points with one response value.

solid-volume image
to produce a colored, three-dimensional solid-block image of the data points, providing an overall view of the data at the volume's border.

direct volume rendering
to create a two-dimensional image of the entire volume of data points with transparency.

BY variable processing
to animate an image so that you can see how response values change according to some grouping, like over time.

To decide which technique to use, consider the type of data. For example, to hold one axis value constant and examine the effect of the other two axis values on the response value, use a cutting plane. To view a subset of data based on response values, use a point cloud.

Note: You can combine multiple images, for example, you can display a point cloud, then a cutting plane. However, if the affect of multiple images is not what you want, be sure to turn off a technique before you request another. △

Color Coding Response Values

When you request a visualization technique, the software displays the response values using the colors from the current data ramp. You can customize the response value ranges and mapped colors as explained in Chapter 4, "Setting Response Value Colors for Images," on page 47.

Image Customizations

To enhance the visualization of data, the global buttons provide such options as image annotations, image transformations, and response value probing. For information, see Chapter 6, "Customizing an Image," on page 73.

Saving an Image

SAS/SPECTRAVIEW allows you to save a displayed image to either a TIFF (Tagged Image File Format) file or a PostScript file, for example, to use in presentations. You can also save current data values to a new SAS data set, for example, to use the new data set with other SAS System products. For information, see "Saving a Displayed Image" on page 85.

# Displaying Response Values as a Point Cloud

One of the first steps in analyzing data is to examine all the data values, for which the point cloud is ideal, for example, to show concentrations of data. A point cloud displays response values as colored markers, showing individual data points. The marker locations represent the plotted values of the X, Y, and Z variables, and the color of each marker represents the range in which that value resides as mapped in the data ramp.

You can display all response values in a point cloud, or you can specify a subset by using the response histogram.

Subsetting Response Values

Using the response histogram, you can specify a subset of response values for a point cloud by setting a range of responses. The response histogram, which appears at the bottom left of the interface when you request a point cloud or an isosurface, displays the frequency distribution of data points that share the same response value. The histogram may also include software-interpolated values between the actual response values.

Display 5.1   Response Histogram to Subset Point Cloud
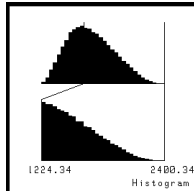
There are actually two histograms:

☐ The upper one represents all the response values in the data set. The positions of the lines are the minimum and maximum response values.

☐ The lower one magnifies the portion of the data that lies between the two lines. The histogram stacks are larger or smaller relative to all the data between the lines. As you move the lines, you alter the span of values being compared to each other, so the stacks in the lower histogram change.

Flat histogram stacks do not necessarily indicate no response data at that value. When you have a complete grid, the flat places may simply indicate much fewer values compared to the frequency of values represented by adjacent stacks. When you have only a few responses and they are widely separated, the values interpolated between them by the software may produce a flat stretch in the histogram.

Displaying a Point Cloud

1 Select ⎡Tools⎤, ⎡Planes⎤, then ⎡Point cloud⎤.

2 To change the shape of the marker, select one from the panel of choices, which include a period, an X, an asterisk, a O, and a +. The default is the asterisk.

3 To change the size of the marker, move the slider below the label **MARKER SIZE**. The default is a moderate size marker. The larger the marker size, the more solid the point cloud.

4 To specify a subset of response values displayed in the point cloud, use the response histogram located in the lower left of the interface:

☐ For a minimum response value, position the cursor on the left line, which represents the low-end values, then drag to the desired lower limit.

☐ For a maximum response value, position the cursor on the right line, which represents the high-end values, then drag to the desired upper limit.

☐ To pan across a subsection of the values, place the cursor inside the lines, then drag the cursor.

Note that you can modify subsetting criteria with a point cloud displayed, but for a lot of data, you may want to turn off the point cloud to speed up the process.

5 Select $\boxed{\text{On}}$.

The following point cloud displays a subset of response values from the EPA data set:

Display 5.2   Point Cloud Displaying Location of High Sulfate Concentrations
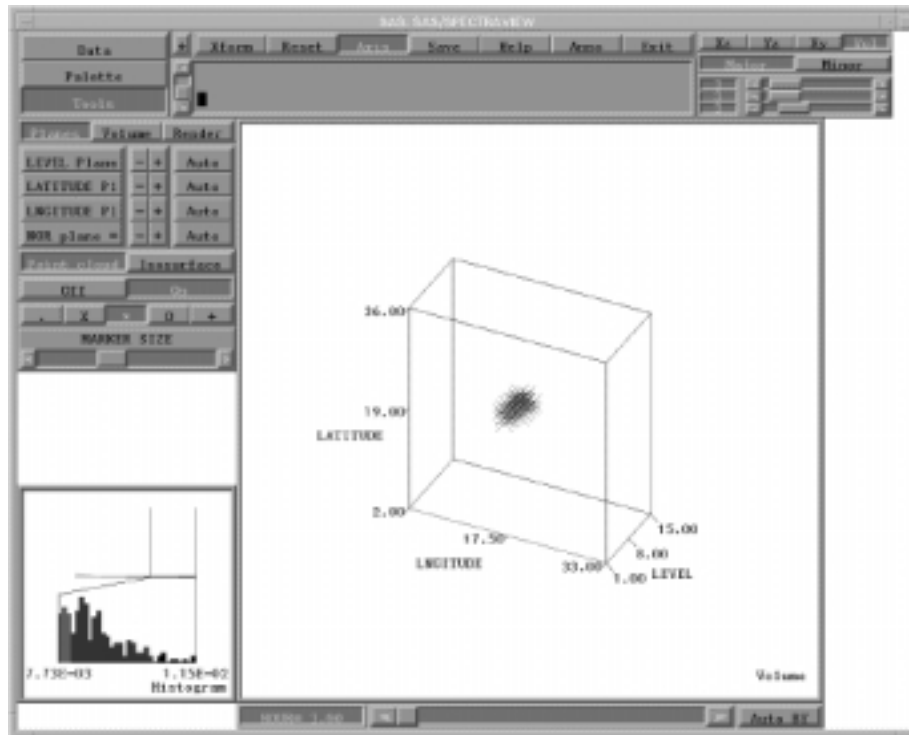
Creating Cut-Away Images with Cutting Planes

Cutting planes provide slices of your data...slicing the data as if with a knife. With cutting planes, you can investigate response values visually slice by slice, as you increment, decrement, or randomly select a position. The face of each slice is colored according to the response values. SAS/SPECTRAVIEW provides:

☐ three axis cutting planes that cut perpendicular to the X, Y, or Z axis, which display in the Volume window. In addition, you can display two- and three-dimensional surface views of the data (such as surfaces, charts, and plots), showing the values at each location along the specified axis, which display in the surface windows.

☐ one NOR cutting plane (non-orthogonal), meaning that the plane is not perpendicular to any axis, which displays in the Volume window.

Displaying an Axis Cutting Plane

The three axis cutting planes cut perpendicular to the X, Y, or Z axis. For example, the Y cutting plane lies parallel to the XZ plane and perpendicular to the Y axis. An axis cutting plane can be displayed in either block contour format (solid-block) or line contour format (continuous lines). To display an axis cutting plane in the Volume window:

**1** Select $\boxed{\text{Tools}}$, then $\boxed{\text{Planes}}$.

The three axis cutting planes are labeled with the variable names you specified for the X, Y, and Z axes. For example, using the MORTGAGE data set and specifying RATE as the X variable, AMOUNT as the Y variable, and YEARS as the Z variable, results in the axis cutting planes:

- ☐ YEARS Plane =>
- ☐ AMOUNT Plane =>
- ☐ RATE Plane =>

The labels for the axis cutting planes also contain a **=>** symbol indicating that the button is a *pull-down button*, which means that pressing the button will display a menu of choices.

2 Position the cursor on the pull-down button representing the axis cutting plane you want to display, then press and hold down the left mouse button to display a menu of choices. *The additional buttons are displayed only while you press the mouse button.*

Display 5.3   Pull-Down Buttons for Axis Cutting Planes
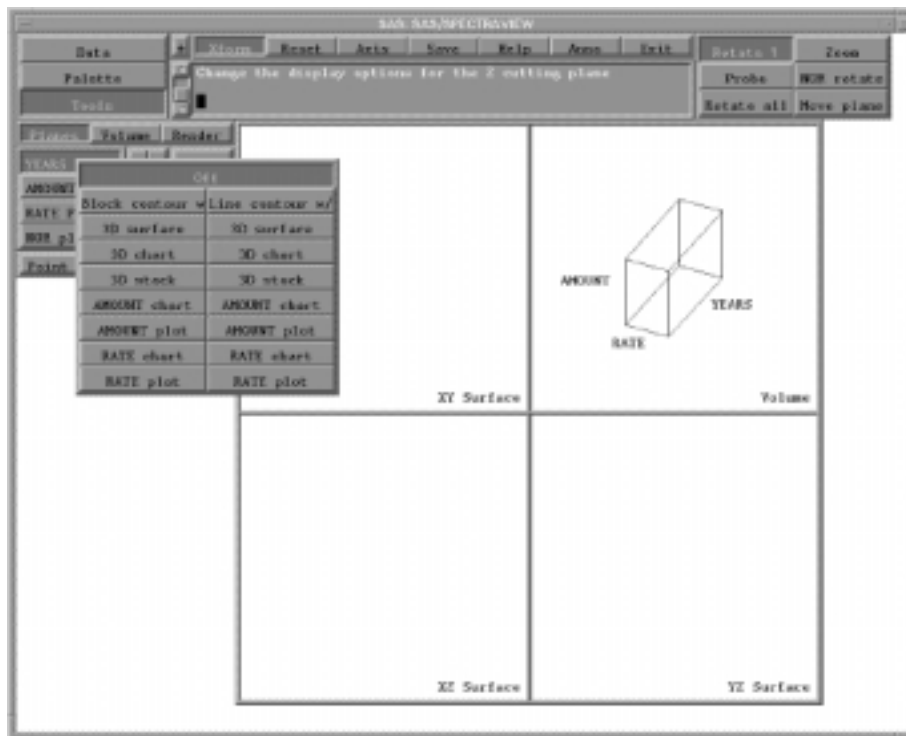
The top choices represent how the cutting plane will be displayed in the Volume window (as solid blocks or line contours), and the bottom choices control which type of image appears in the surface window.

3 Drag the mouse to one of the following choices, then release the mouse to select it:

Block contour w/
> to display the cutting plane in a solid-block format. Note that for sparse data, a block-contour image may appear as separate blocks, because each block represents one data point in the current plane.

Line contour w/
> to display the cutting plane as continuous lines. Note that a line-contour image needs at least four data points at each grid intersection to be displayed, which may not exist for sparse data.

| Off |
to turn off the displayed cutting plane.

You can display more than one cutting plane at a time in the Volume window, up to the four types. *If there is no data for the cutting plane's current location, the cutting plane will not display, unless you have assigned color to missing values.*

   In the following example, which uses the MORTGAGE data set, the response values (for PAYMENT) are displayed against the Z cutting plane by selecting | YEARS Plane=> | then | Block contour w/ |. The cutting plane shows the impact of varying interest rate and loan amounts for a given year. That is, the year is held constant and the impact of the other two variables on the payment amount is shown. You can move the cutting plane over the range of years to examine other combinations based on a given year value.

Display 5.4   Y-Axis Cutting Plane
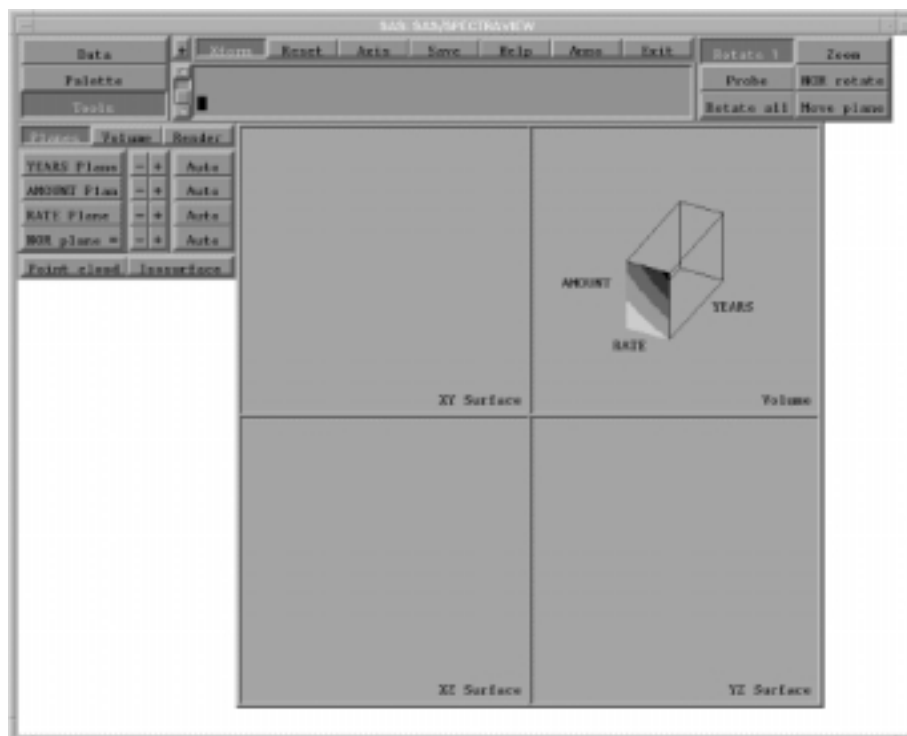
Including Surface Views for an Axis Cutting Plane

   You can display two- and three-dimensional surface views of data, such as surfaces, charts, stacks, and plots. The surface views represent the data at a selected cutting plane's current location, and they display in an appropriate surface window. To request a surface view:

1 Select | Tools |, then | Planes |.

   The three axis cutting planes are labeled with the variable names you specified for the X, Y, and Z axes. For example, for the MORTGAGE data set, RATE is the X variable, AMOUNT is the Y variable, and YEARS is the Z variable, which results in the axis cutting planes

   □ | YEARS Plane => |

□ AMOUNT Plane =>
□ RATE Plane =>

The labels for the axis cutting planes also contain a **=>** symbol indicating that the button is a *pull-down button*, which means that pressing it will display a menu of choices.

2 Position the cursor on the pull-down button representing the axis cutting plane you want to display, then press and hold down the left mouse button to display a menu of choices. *The additional buttons are displayed only while you press the mouse button.*

Display 5.5 Pull-Down Buttons for Surface Views
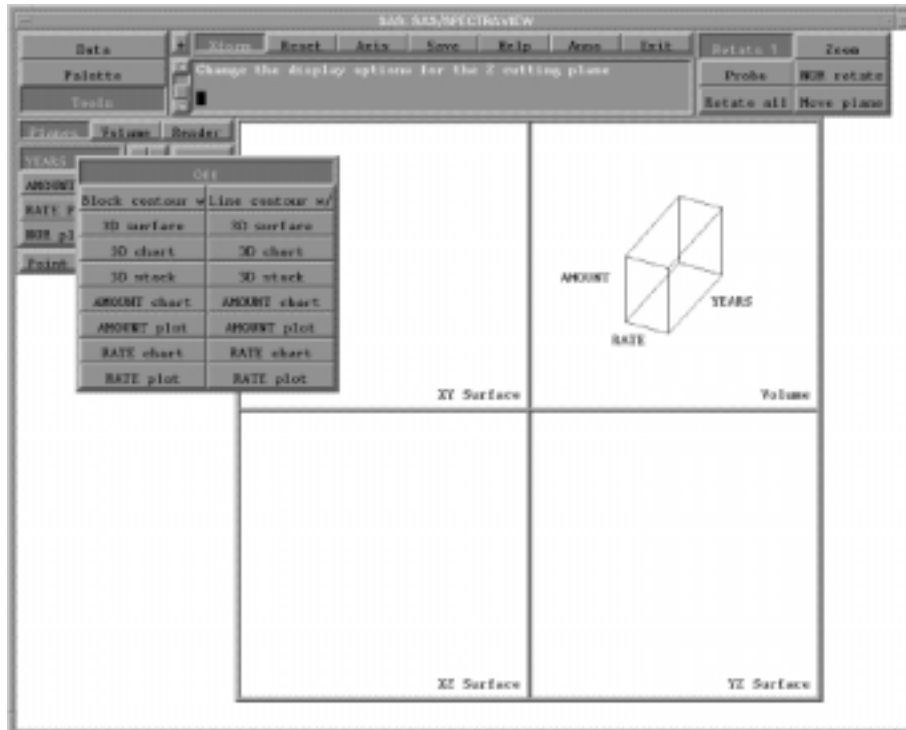
The top choices represent how the cutting plane will be displayed in the Volume window (as solid blocks or line contours), and the bottom choices control what type of image appears in the surface window.

3 Drag the mouse to one of the following choices, then release the mouse to select it:

3D surface to create a three-dimensional surface of the axis cutting plane. The third dimension is response.

3D chart to create a three-dimensional chart of the axis cutting plane. The third dimension is response.

3D stack to create a three-dimensional stacked line contour of the axis cutting plane. The third dimension is response.

For the respective axes:

axis chart to create a two-dimensional bar chart of the responses across all values of the axis. For example, for the X cutting plane, selecting the Z chart produces a color chart of the responses across all values of Z at the current X location of the cutting plane. The Y value remains constant at its current value.

axis plot	to create a two-dimensional plot of the response values across all values of the axis. For example, for the X cutting plane, selecting the Z plot produces a color plot of the responses across all values of Z at the current X location of the cutting plane. The Y value remains constant at its current value.

The image displays in the appropriate surface window in solid-block format. That is, a surface view of a cutting plane along the Z axis displays in the XY Surface window, a cutting plane along the Y axis displays in the XZ Surface window, and a cutting plane along the X axis displays in the YZ Surface window. *Note that when you request a surface view, if its associated axis cutting plane is not already displayed, it automatically displays in the Volume window.*

In the following example, a three-dimensional chart is displayed in the XY Surface window by selecting YEARS Plane=> (Z cutting plane), then 3D chart . The chart is linked to the Z cutting plane's current position.

Display 5.6 Three-Dimensional Chart in XY Surface Window
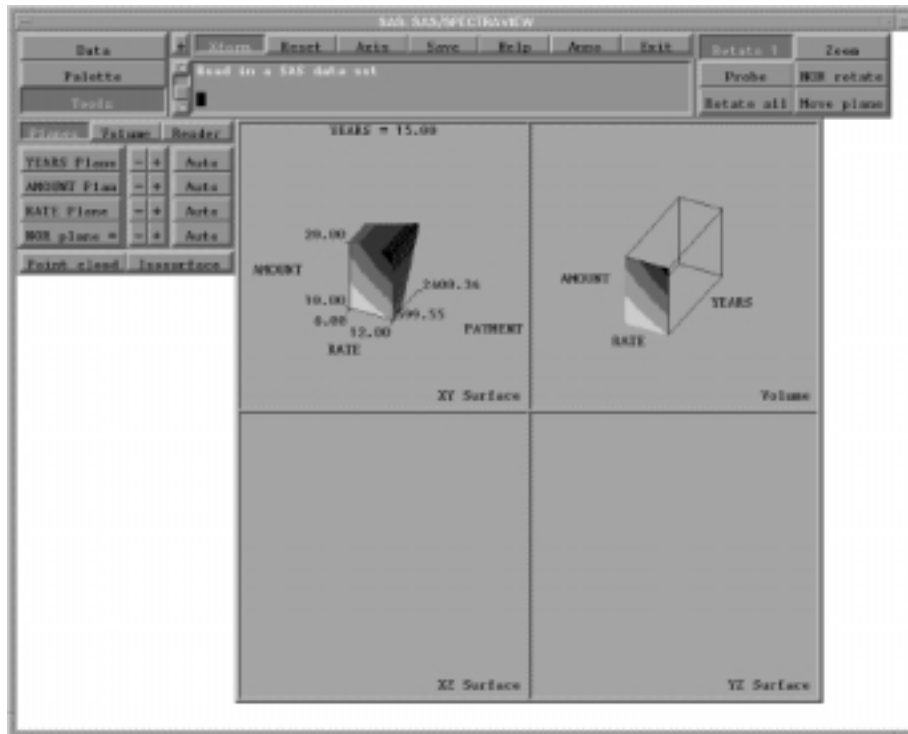
Displaying a NOR Cutting Plane

The NOR cutting plane (non-orthogonal) is not perpendicular to any axis. You can use the NOR cutting plane to cut the data in any manner you wish. It displays in block contour only. To display the NOR cutting plane in the Volume window:

1 Select Tools , then Planes .

The labels for the cutting plane buttons contain a **=>** symbol indicating that the button is a *pull-down button*, which means that pressing it will display a menu of choices.

2 Position the cursor on the NOR plane => pull-down button, then press and hold down the left mouse button to display a menu of choices. *The additional buttons are displayed only while you press the mouse button.*

3 Drag the mouse and select Block contour to display the cutting plane in a solid-block format. (Selecting Off turns off the displayed cutting plane.)

In the following example, using the MORTGAGE data set, the NOR cutting plane is displayed along with the Y cutting plane.

**Display 5.7**   NOR Cutting Plane
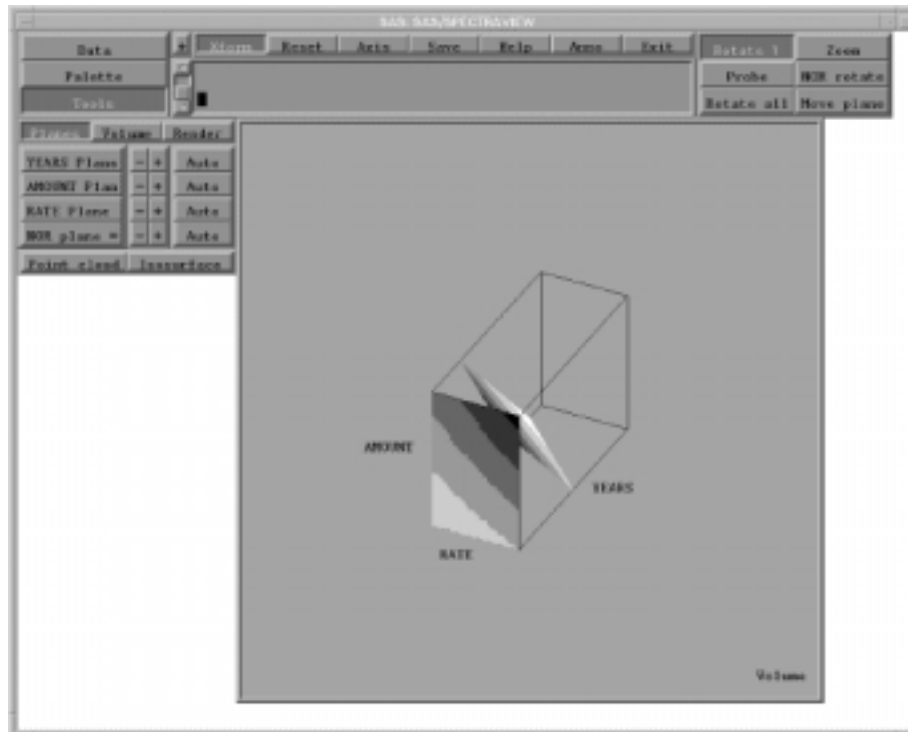
Moving a Cutting Plane

The initial position of a cutting plane shows a section at the minimum value for the axis. Moving a cutting plane lets you view the data slice by slice, allowing you to position a cutting plane at a specific location along the axis.

As you move a cutting plane, the data at the various locations along the axis displays against the cutting plane and in any two- or three-dimensional surface views. *If there is no data for the cutting plane's current location, the cutting plane will not display, unless you have assigned color to missing values.*

☐ To automatically move a displayed cutting plane continuously along its axis, select Auto. The response values display against the cutting plane as it moves through the volume grid, stopping at each unique value for the axis. Only one plane at a time can move continuously. (To make the plane stop moving, click the left mouse button.)

☐ To manually move a cutting plane to a specific point on the axis by stepping it through the data incrementally, use the − (backward) and + (forward) buttons.

Or, select the Xform global button, select either Move plane (for the axis cutting planes) or NOR rotate (for the NOR cutting plane), drag the cursor along the axis to the appropriate point, and release the mouse button.

Display 5.8 Moved Cutting Plane
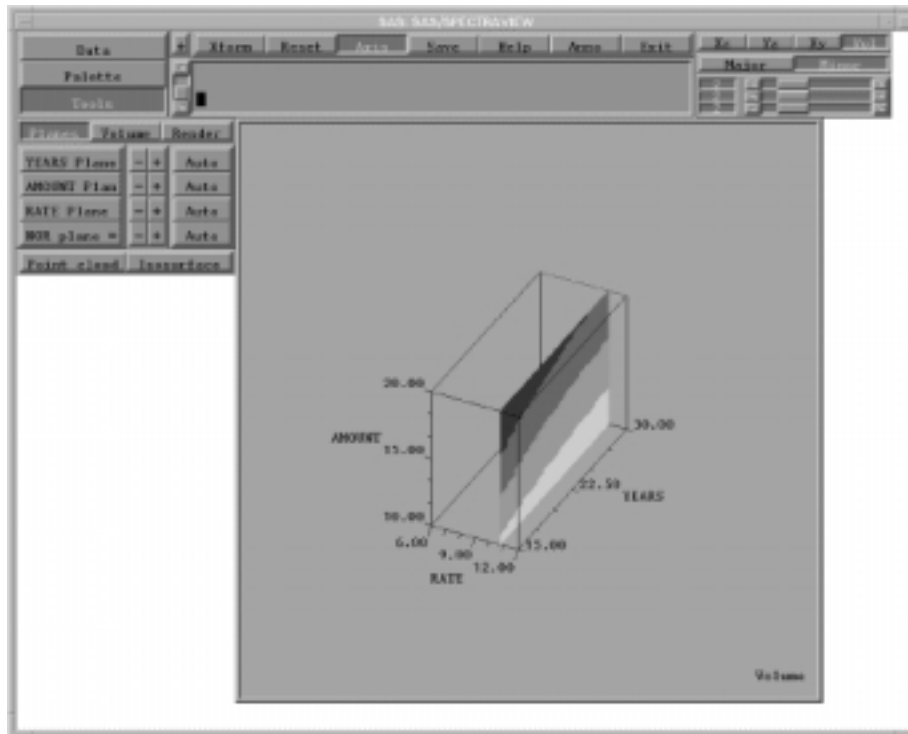

Viewing a Response Value as an Isosurface

An isosurface produces a three-dimensional surface by connecting all the data points with one response value. That is, the isosurface lets you see all locations in the volume grid when the response values are equal. An isosurface is particularly useful in viewing scientific data and physical properties such as temperature, density, and stress.

You must specify the response value to be displayed by the isosurface using the response histogram. The value shown corresponds to the lower histogram level.

Isolating a Response Value

With the response histogram, you specify the response value for an isosurface. The response histogram, which appears at the bottom left of the interface when you request a point cloud or an isosurface, displays the frequency distribution of data points that share the same response value. The histogram may also include software-interpolated values between the actual response values, which can be used to generate an isosurface.

Display 5.9 Response Histogram to Specify Isosurface Value
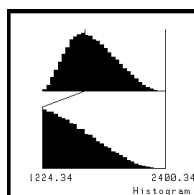
There are actually two histograms:

☐ The upper one represents all the response values in the data set. The positions of the lines are the minimum and maximum response values.

☐ The lower one magnifies the portion of the data that lies between the two lines. The histogram stacks are larger or smaller relative to all the data between the lines. As you move the lines, you alter the span of values being compared to each other, so the stacks in the lower histogram change.

Flat histogram stacks do not necessarily indicate an absence of response data at that value. When you have a complete grid, the flat places may simply indicate much fewer values compared to the frequency of values represented by adjacent stacks. When you have only a few responses and they are widely separated, the values interpolated between them by the software may produce a flat stretch in the histogram.

Displaying an Isosurface

1 Select ⬜Tools⬜, ⬜Planes⬜, then ⬜Isosurface⬜.

2 To specify the response value, use the left mouse button and drag the histogram's left line to the desired value. The default position of the left line is the minimum response value, which cannot be used to generate an isosurface. (The right line has no effect on an isosurface specification.)

3 Render the isosurface by selecting:

⬜W/ depth sort⬜
displays the isosurface with depth sorting by sorting the planes front-to-back so that the image appears more realistically three-dimensional, for example, when moving planes through the volume grid. This method takes more time.

⬜W/o depth sort⬜
displays the isosurface without depth sorting, which is a faster, but less realistic method. *It is recommended that you use this method when animating an isosurface with a BY variable to produce faster animation.*

⬜Off⬜
turns off the displayed isosurface.

By default, the isosurface is drawn in the color shown in the histogram for the selected response value.

4 To assign a different color to the isosurface, select ⬜Palette⬜, ⬜Isosurface⬜, then ⬜User-defined⬜. Adjust the RGB sliders. As you move the sliders, the current color appears in a square at the left, and the isosurface changes color in the Volume window. *You can also select a color chip, located below the RGB sliders.* (To return to the response value color, select ⬜Response level⬜.)

Display 5.10   Isosurface
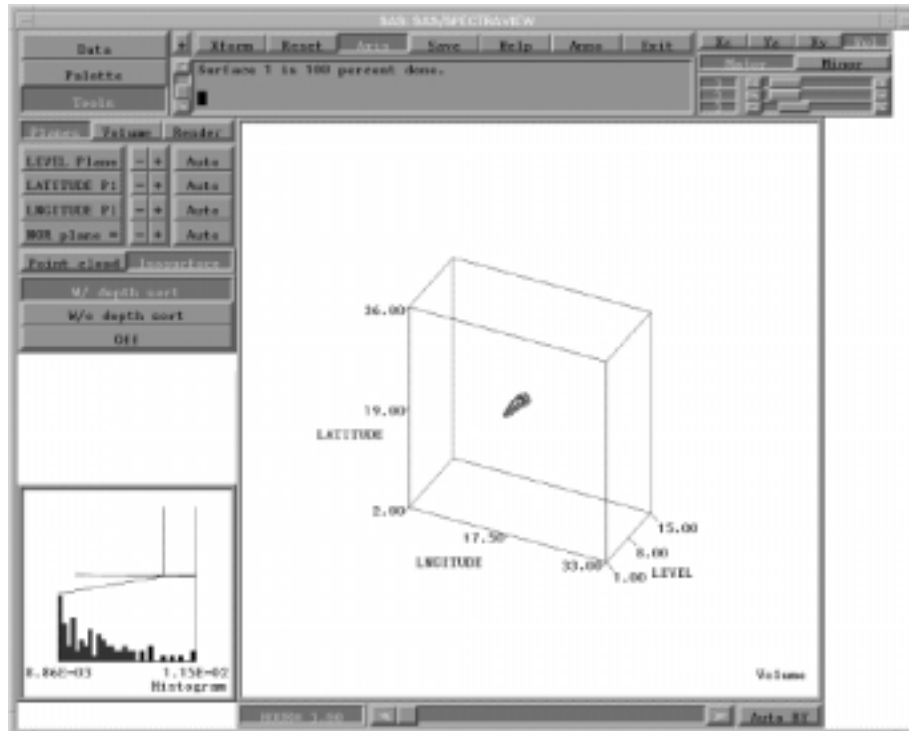
Note that you can specify a different response value when the isosurface is turned on or when it is turned off. However, if you have a large amount of response data, it may be faster to turn off the isosurface, then adjust the histogram.

Effect of a BY Variable on an Isosurface

For an isosurface with a BY variable specification, you can request a specific response value but not see the isosurface display. This is because the response value you selected is not contained in the data associated with the current BY value. (The histogram shows all responses, in ascending order, regardless of the value of the BY variable.)

To see the isosurface that was generated, use Auto BY to search for the appropriate BY value. Because the response value may be valid for more than one x,y,z location over time, an isosurface may be generated for more than one BY value. When the applicable BY value(s) is current, the isosurface is clearly visible.

Displaying Data as a Solid-Volume Image

Displaying data as a solid-volume image produces a colored, three-dimensional solid-block image of the data points, providing an overall view of the data. The technique displays the response values at the bounds of the volume grid. *Note that to view interior data, you can specify a subset of the volume.* To display a solid-volume image:

1 Select Tools .

2 Select Volume . The image displays in the Volume window.

Display 5.11   Solid-Volume Image
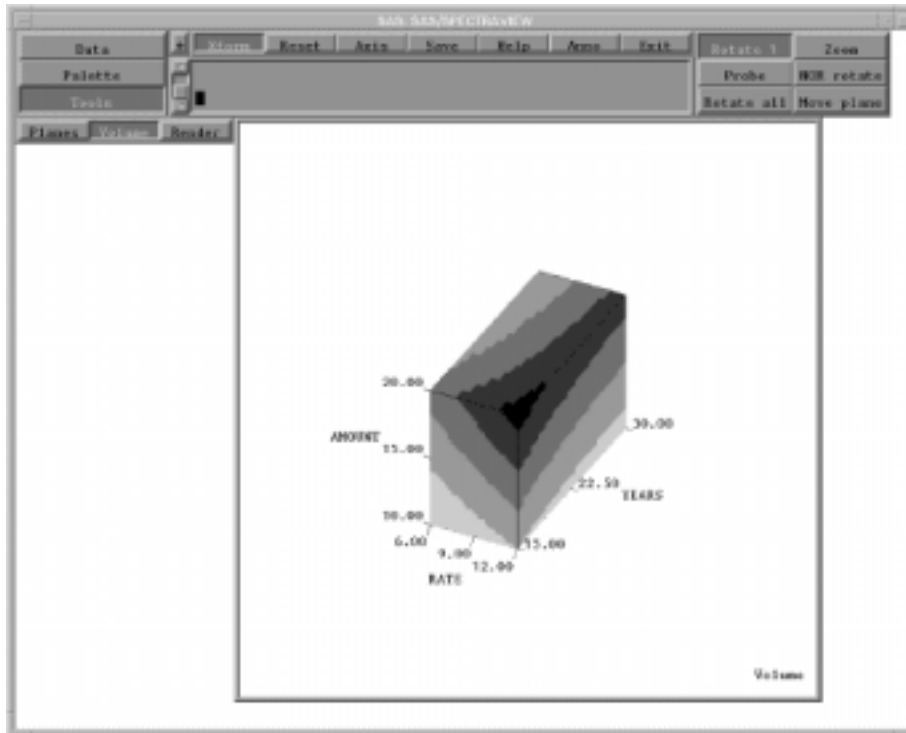
Note that from the Xform global button, you can select the Rotate 1 button to change the angle of the image by dragging the cursor along any of the three axes or the Move plane button to increase or decrease the area of volume by dragging the cursor along any of the three axes.

Rendering a Volume and Saving as a Two-Dimensional Image

Direct-volume rendering creates a two-dimensional image of the entire volume of data points with transparency displayed in the Volume window, which you can then save to a file.

You can render an image using either the Splat option or the Scanline option:

Splat   renders each response value using a technique that is much like splatting a snowball against the cutting plane as it moves through the volume grid.

Scanline   renders the image or images displayed in the Volume window as a high-quality, three-dimensional image.

Note that before rendering, consider changing the size of the Volume window so that the resulting image is larger or smaller. For example, for many data points, reducing the window size improves rendering time, whereas increasing the window size can provide a better view of dense data. For instructions, see "Resizing the Display Windows" on page 86.

Requesting Splat Rendering

Specifying the Splat option renders each response value using a technique that is much like splatting snowballs against the cutting plane as it moves through the volume grid...each data point is a snowball. You have the option of setting an opacity degree and a splat width.

To create a splat rendered image:

1 Select Tools , then Render .

2 In the Opacity window, which is located at the bottom of the interface, adjust the opacity line to specify a degree of opacity or transparency for response values with the various color ranges. That is, visibility of data points in the rendered image is determined by the location of the opacity line corresponding to the colors of the data points.

To adjust the opacity degree, use the cursor to drag portions of the opacity line to the top or bottom of the window:

☐ Colors represented on the line at the top of the window are rendered with a high opacity, making the colored data points more opaque (clearly visible in the rendered image). To make a specific range of responses more visible in the rendered image, drag those colors to the top of the window.

☐ Colors represented on the line at the bottom of the window are rendered with a low opacity, making the colored data points more transparent (invisible in the rendered image). To exclude responses from the rendered image, drag those colors to the bottom of the window.

Note that you can reset the opacity line to its default degrees by selecting the Reset global button, then the All button. However, the All button resets the entire software to its defaults, so use it cautiously.

3 To set the size of the rendered data points, which determines how solid the rendered image is to be, adjust the splat width by dragging the slider to the right for a larger width or to the left for a smaller width. *The larger the splat width, the more solid the resulting image.*

4 Select Splat to initiate the rendering process.

5 Once the image is rendered, you are prompted to enter a filename in the text window. *The file type depends on the specification from the Save global button.* The default is a TIFF file.

6 To bypass the filename prompt or to clear the rendered image, press Enter.

Display 5.12   Splat Rendered Image
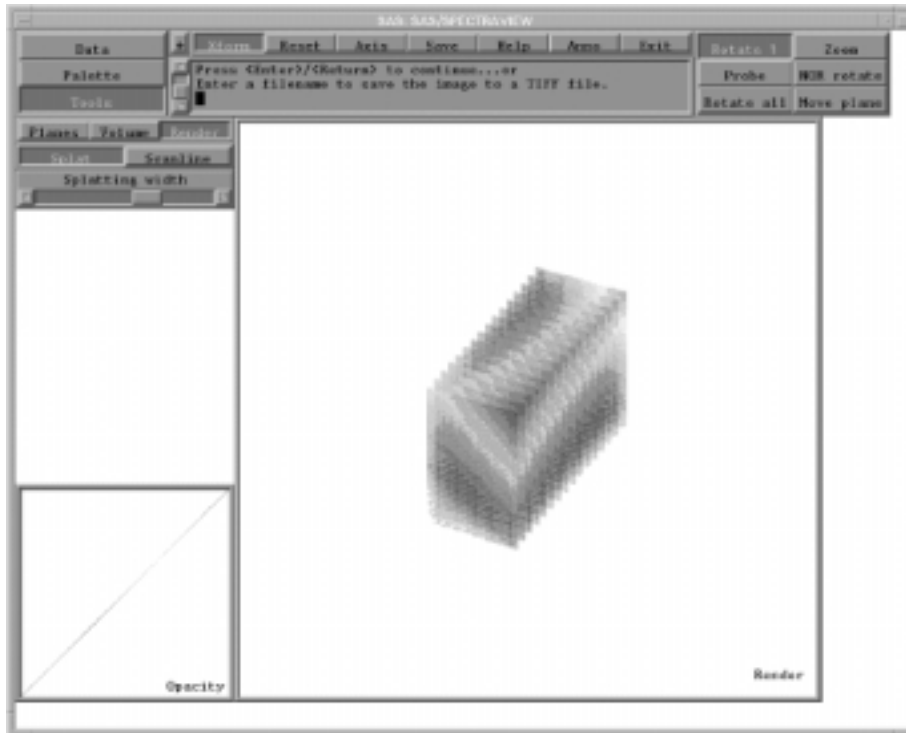
Note that when you request splat rendering, the software renders all response values even if you have a subset of response values displayed in a point cloud.

Requesting Scanline Rendering

Specifying the scanline option renders the image displayed in the Volume window as a shaded, solid object, showing the effects of a light source. An isosurface and cutting planes are rendered as solid, Gouraud-shaded images.

For example, if you request an isosurface, rendering it using scanline produces a solid image from the wireframe one, which will show more clearly how the surface changes. In addition, a scanline rendering of a cutting plane is smoother.

To create a scanline rendered image:

1 Use a visualization technique to display an image or images in the Volume window, for example a point cloud.

2 Select $\boxed{\text{Tools}}$, then $\boxed{\text{Render}}$.

3 Select $\boxed{\text{Scanline}}$ to initiate the rendering process.

4 Once the image is rendered, you are prompted to enter a filename in the text window. *The file type depends on the specification from the Save global button, with the default being a TIFF file.*

5 To bypass the filename prompt or to clear the rendered image, press Enter.

Display 5.13   Scanline Rendered Image
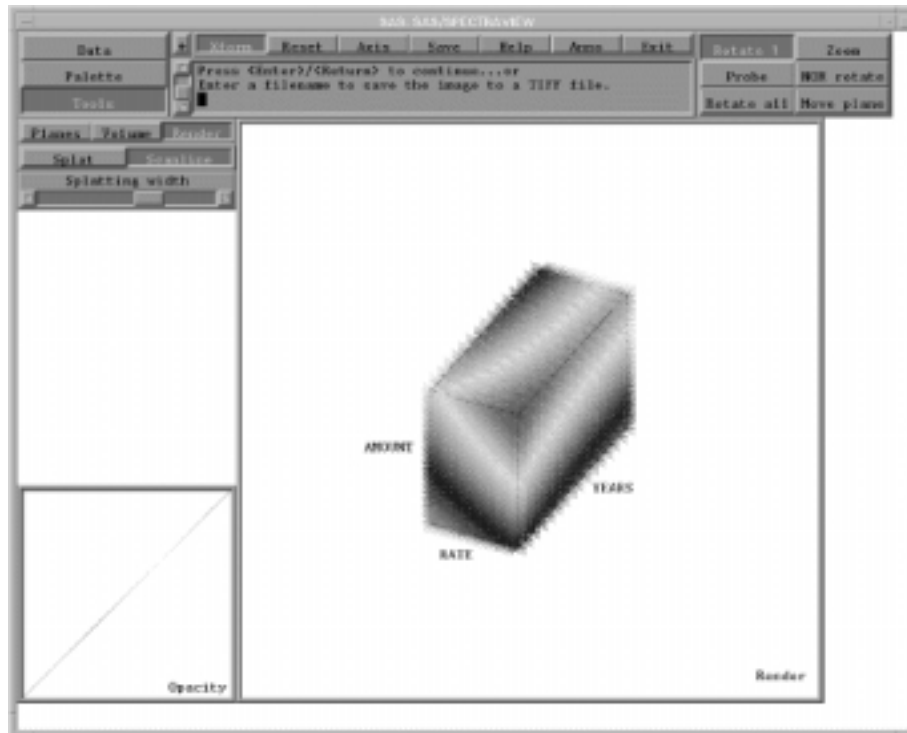
Animating an Image with a BY Variable

With a BY variable assigned, you can animate an image in the Volume window. The values of a BY variable define groups of observations, such as hour, month, or year. Specifying a BY variable lets you see how response values change according to some grouping, like over time.

For example, if the specified BY variable is the hour of the day and a point cloud is displayed showing the amount of sulphur in the air at various coordinate locations, the point cloud reflects the amount of sulphur for the locations at 9 o'clock, 10 o'clock, and so on.

To produce animation with a BY variable:

1 First, you must specify a BY variable when you load the data. For instructions, see "Grouping Observations with a BY Variable" on page 28.

2 Use a visualization technique to display an image, such as a cutting plane, a point cloud, or an isosurface.

3 To automatically move through the BY variable values, which animates the current image, select ⬚Auto BY⬚, which is located at the bottom right of the interface. The values for the BY variable appear at the left of the BY variable slider, changing as the software moves through the values. (To stop the animation, click the left mouse button.)

   To manually move through the BY variable values, for example, to see the image at a specific value, drag the BY variable slider, which appears below the display windows, to the left of ⬚Auto BY⬚.

For example, using the EPA data set and specifying HOUR as the BY variable, the following isosurface shows high sulfate concentrations at hour 23.

Display 5.14 Specified BY Variable