

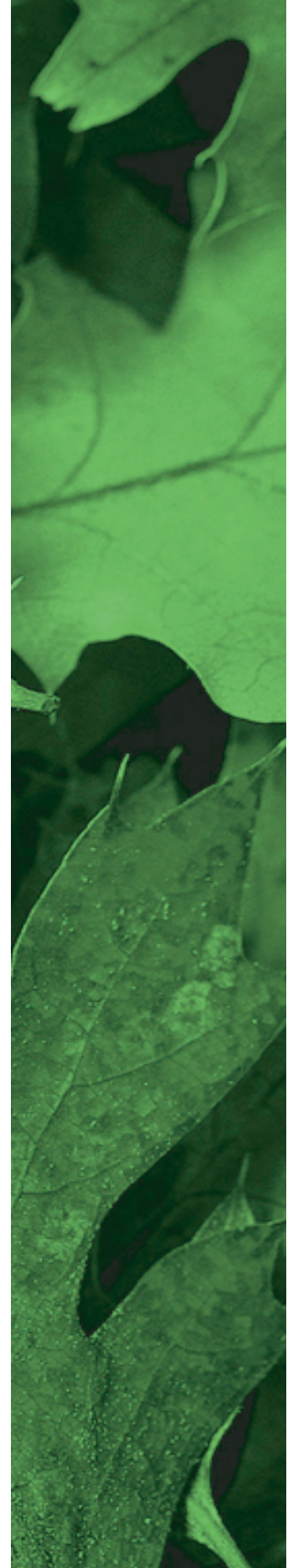
Studying Earth's Environment
From Space
Module 2: Global Land Vegetation

Using S E E Image with AVHRR Data

TUTORIAL

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NASA Goddard Space Flight Center
Earth Sciences Directorate
Scientific & Educational Endeavors (see)
helpdesk@daac.gsfc.nasa.gov



Tutorial written, edited, and produced by
Ned Horning, Barbara Gage, and Diana Sunday

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Scientific & Educational Endeavors
NASA Goddard Space Flight Center
Greenbelt, MD 20771

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SEE Image is a Macintosh public domain image processing package based on an existing program, NIH Image, that was developed at the National Institutes of Health to serve primarily as a medical imaging program. NIH provides a manual, tutorial, list of frequently asked questions (FAQs) and the NIH Image software from their Website:
<http://rsb.info.nih.gov/nih-image/>

Modifications were made to the NIH Image software source code to allow special processing for satellite image data. New functions were added to the NIH code, but none were removed. For this reason most SEE Image macros will not work with the original NIH Image.

You'll need a color Macintosh running System 7.0 or later. A Mac with 8 megabytes (MB) or more of RAM is recommended, although a 4-MB system will work if virtual memory can be used. Make sure that *at least 2 MB* of RAM are made available for SEE Image (you may have to quit other programs) as that is the minimum it needs to operate. Some exercises require more than 2 MB of RAM.

Executor is a Macintosh emulator produced by ARDI that allows you to run SEE Image on a PC. For more information about Executor, visit the ARDI Website: <http://www.ardi.com>.

SEE Image can work with large monitors, flatbed scanners, film recorders, graphics tablets, PostScript laser printers, phototypesetters, and color printers and it can be used in concert with various graphic, spreadsheet, and graphing programs. The NIH Image manual and tutorial describe how they may be used with NIH Image and thus with SEE Image.

NIH Image, thus SEE Image, works only with 8-bit data (256 values). For image display or for comparative analysis, such as that which will be conducted in this tutorial and the accompanying exercises, this limit will not pose a problem. However, should you wish to do rigorous scientific analysis that requires more numerical precision than 8 bits per pixel, it's beyond the capabilities of this software.

before we begin

what is see image

macintosh system requirements

mac emulator for pc

using other software and peripherals

program limitations

SEE Image reserves pixel value 255 for the color black and pixel value 0 for white as system colors. Consequently, if you have a data set with more than 254 values the data are linearly scaled from 1 to 254 and an approximate pixel value for the original image is calculated and displayed. These approximate pixel values can have a slight error, although the approximated values shouldn't vary by more than

$$\frac{(\text{max-min})}{254}$$

where max and min are the maximum and minimum pixel values in the data set.

terms used in the tutorial and exercises

Clicking refers to pushing and releasing the mouse button. If your mouse has more than one button, use the left one.

Pull Down means clicking and holding down the mouse button then dragging the cursor from the menu to your choice of options and releasing the button. Example:

Pull down the
FILE
menu and choose
Save

Activating an image or window is done by clicking on it. An active window will have a pattern (usually horizontal lines) in the title bar across the top of the window. Inactive ones have white title bars.

Selecting a window is the same thing as activating.

Check Boxes are represented by a small square and are chosen by clicking in the box you want—an X or a check mark will then appear inside the box. You can turn them back off by clicking on the Xs or check marks.

Radio Buttons are circles that work the same way as check boxes. When you select one, a black (or color) dot will appear inside the circle. Only one radio button in a series can be selected at a time.

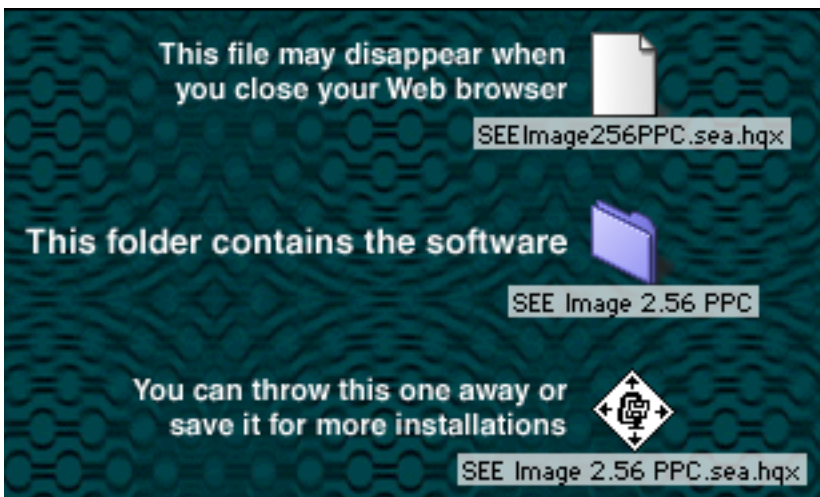
Go To a file or folder by following a specified path. Example:
Desktop | your hard drive | the main SEE Image folder | next item of choice | etc.
Navigation paths will appear this way throughout the tutorial.

For SEES Web site users, go to

<http://see.gsfc.nasa.gov/edu/SEES/>

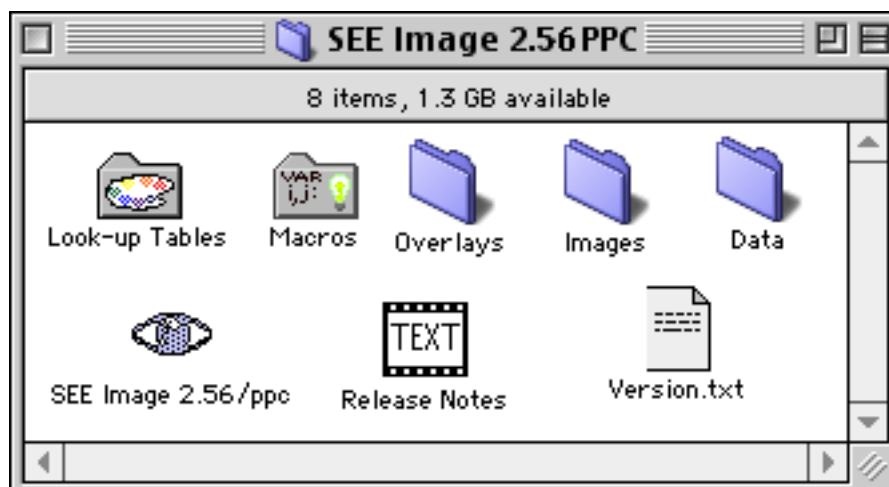
Under **Global Land Vegetation**, click **Computer Resources** then click **Software**. Downloading instructions are given on the site. Follow them, then sit back and relax while the file downloads. Once the download is complete, the following icons will appear on your desktop.

1 installing see image

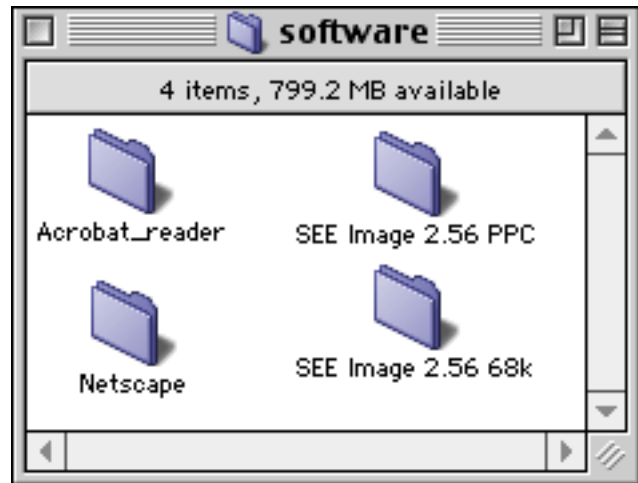


NOTE: The software is updated occasionally. The number after “SEE Image” indicates the version. Please check the Website periodically for the newest version.

You now have a folder labeled SEE Image on your desktop that contains the program (whose icon is an eye), some Release Notes, a “version.txt” file, and five folders. Drag that folder onto your hard drive.



For SEES CD users, go to the main window and double click the Software folder. Choose the SEE Image version that matches your computer type. Drag that folder onto your hard drive.



1.1 setting up your computer

Pull down the



menu, choose

Control Panels

then choose

Monitors & Sound (Moniitors)

and set the colors to “thousands” or “millions.”

If your hardware doesn't offer this option, you can still run SEE Image using 255 colors, but your desktop colors may change. It's not permanent. Your desktop colors will reset to your original choices when you quit SEE Image.

SEE Image will install with just enough memory allocated (~11 MB) to run the exercises. If you want to import more images than what is used in this tutorial or the exercises, you'll need to increase this amount or you'll get error messages while loading or creating images.

To increase the memory, click once on the SEE Image eye icon to highlight it, pull down the

FILE

menu and choose

Get Info

Increase the number in the Preferred Size box at the bottom right.

NOTE: Even if you don't get error messages, it's a good idea to increase the memory allocation if you have enough available. All software works better and often faster with more room to move.

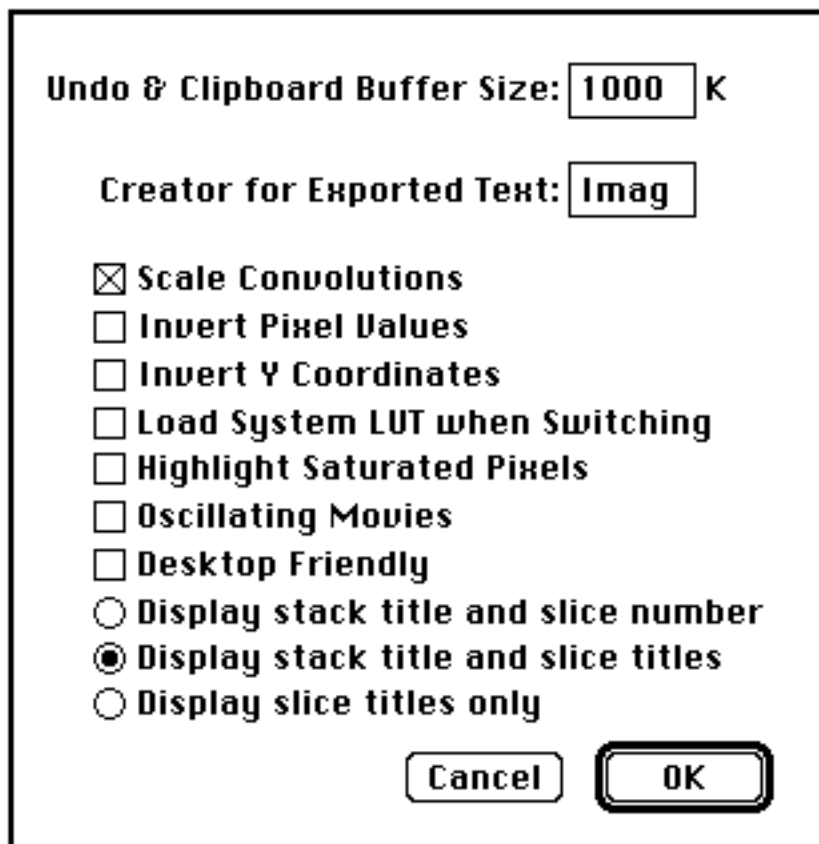
Double click the eye icon to launch the program then pull down the

OPTIONS

menu, choose

Preferences

set it up exactly as shown, and click OK.



Next pull down

OPTIONS

again and choose

Grayscale

then pull down the

FILE

menu and choose

Record Preferences

to save your settings.

Now pull down

ANALYZE

and choose

Options

Be sure that "Mac Measurements (1–8000)" is set at 256 or higher.

Set "Digits Right of Decimal Point (0–8)" at 2.

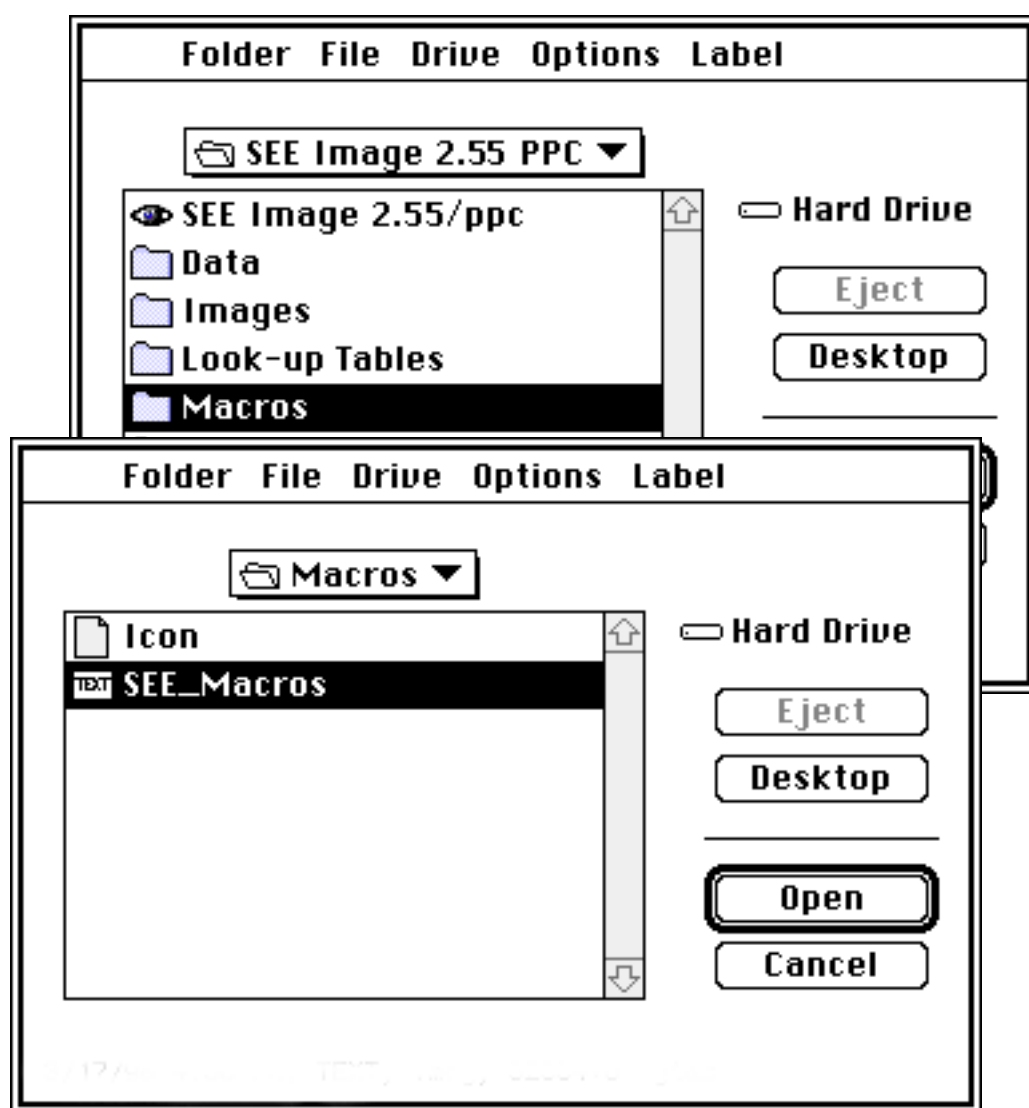
2 configuring see image

If you made changes at this point you'll get a message saying that the changes will take place the next time you start SEE Image. Quit and restart the program.

3 loading the macros developed for this tutorial

Special programs called macros were designed specifically for working with global land vegetation data. Macros either perform specific tasks unavailable in the original software or automate a series of steps that are tedious if performed manually.

Pull down
 SPECIAL
and choose
 Load Macros
Highlight and Open as shown.



To verify that the macros loaded correctly, pull down **SPECIAL** again. Macro names will now be visible at the bottom part of the menu.

NOTE: Every time SEE Image is started the macros will have to be loaded.

For SEES Web site users, go to

<http://see.gsfc.nasa.gov/edu/SEES/>

Under **Global Land Vegetation**, click **Computer Resources**. Then click **Data** and download the data for the Tutorial. When the download is complete and the archive is unpacked, which will occur automatically, you'll see three new icons on your desktop. Two are document icons that will have one of these file name extensions: *.sea.hqx* or *.sea*. You may trash those files. The other is a folder labeled **vgtutor**. Drag that folder into

Desktop | your hard drive | SEE Image | Data | Veg

For CD users, go to

Desktop | SEES | data | veg

then click and drag the **vgtutor** folder into the **Veg** folder as described above.



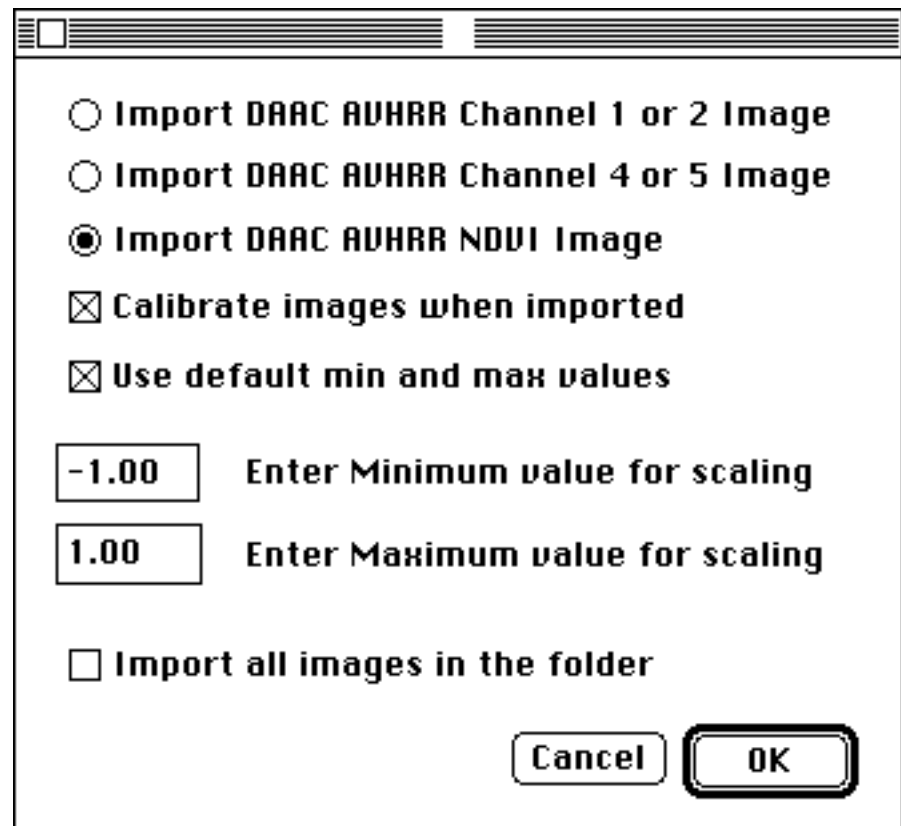
4 accessing global vegetation data

5 displaying avhrr ndvi data with see image

5.1 image input

SEE Image has several programs that aid visualization of images. These programs can be used to identify specific pixel locations, zoom in and pan around an image, change map projections to minimize distortions, subset an image, apply overlays, color with Look-Up Tables, annotate, and so forth.

Pull down
FILE
and choose
Import DAAC AVHRR
then set up as shown and click OK.



These settings will remain until you change them.

When the image is imported it will appear as a grayscale image. The above settings assigned the range of image values to be linearly displayed in tones of gray in screen values from 1–254. Remember that the system reserves screen value 255 for pure black and screen value 0 for pure white. The defined image values are then displayed in grayscale. Values greater than the maximum are white and values less than the minimum are black.

Go to

Desktop | your hard drive | SEE Image | Data | Veg | vgtutor | ND930101
and click **Open**.

This will give you the first 10-day composite NDVI image for January displayed as a grayscale image named **ND930101**. There will be black regions on the image that represent areas with “no data” values.

Graphic overlay in SEE Image is done in a “destructive” manner. That is, when a graphic object—lines, text, continent boundaries—is overlaid on an image the pixels under the graphic object are replaced with the pixel value of the graphic itself. For this reason, it’s important to use graphics with care, and don’t use images with graphics for analysis. The white areas of the overlay are transparent and do not alter the data values.

Pull down

FILE

and choose

Open

Go to

Desktop | your hard drive | SEE Image | Data | Veg | vgtutor | Rond0982.tif
and click **Open**. A small image of the Brazilian state of Rondonia will appear. Next, choose **Open** and go to

Desktop | your hard drive | SEE Image | Data | Veg | vgtutor | Roads.tif
and click **Open**. An image with some roads (a series of lines) will be displayed.

Activate the roads image (Roads.tif) by clicking in its image window then pull down

EDIT

and choose

Select All

Go back and pull down

EDIT

again and choose

Copy Selection

Then activate the Rondonia image (Rond0982.tif) by clicking in its window, pull down

EDIT

and choose

Paste

5.2 overlaying graphics on an image

prerequisites:
steps 1–5.1

The overlay image will completely cover the base image at this point.

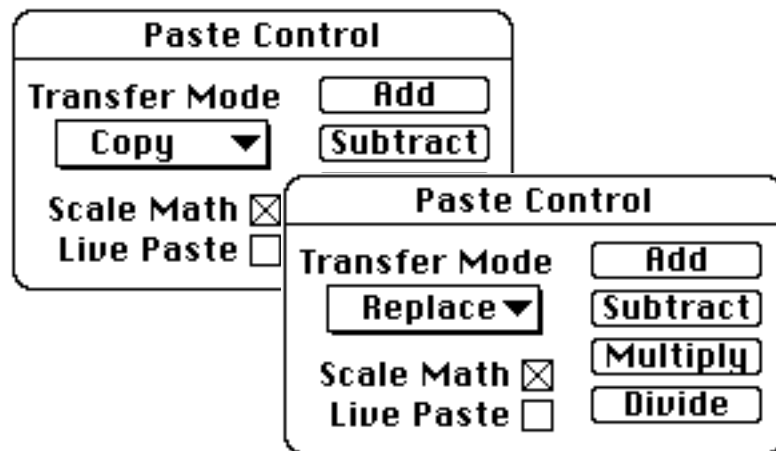
To finish the overlay, pull down

WINDOWS

and choose

Show Paste Control

While in the Paste Control window, click and hold the Transfer Mode button (with COPY as the default) and select Replace.



Then close the Paste Control window by pulling down

WINDOWS

and choosing

Hide Paste Control

WARNING: It's important not to click on anything before selecting "Paste Control." Doing so can move the paste image (the overlay) or will terminate the Paste session. You'll know if the Paste session terminated because when you try to do the next step you'll get the error "Paste Control is only available during paste operations." If this happens, pull down EDIT and select Undo Paste then repaste the overlay image.

When finished, close the Roads.tif and Rond0982.tif images by clicking in the square "close" box in the upper left corner of the image window.

Click inside the window of the first 10-day composite NDVI image for January (ND930101). (A window is active if the white bar at the top of the image window has horizontal lines in it.) Then look at the Info window at the left under the toolbar. If the Info window isn't visible, pull down

WINDOWS

then choose

Info

to bring it to the front of the screen. After selecting the Info window, remember to click in the image window to make it active again.

Move the cursor around in the image and observe how the Value and X and Y coordinates change. The Info window provides information about the pixels located under the cursor. Move the cursor to the upper left corner of the image and verify that the X Y values are 0 for X and 0 for Y. If this is not the case, it's likely that the Preferences are not set correctly (see p. 9).

NOTE: The Y coordinate is inverted from what you may be accustomed to seeing. In a typical graph, both X and Y zero is normally at the *lower* left corner. SEE Image puts Y=0 at the top left.

Also inside the Info window is a "Value" with two numbers after it.

As mentioned previously, SEE Image is limited to displaying pixel values from 0 to 255. SEE Image deals with this limitation by displaying the NDVI or channel value and the SEE Image value for each pixel. The NDVI or channel value is displayed immediately after Value; and the SEE Image value is in parentheses. For these exercises, we will be concerned with the approximate (scaled) values.

Move the cursor over an area represented by a patch of black pixels. You'll notice that the value is -1. These pixels represent areas of no data.

5.3 pixel location, ndvi values, and no-data pixels

prerequisites:
steps 1–5.2

If more than one image is displayed, you can apply the selected LUT to all open images by pulling down

OPTIONS

choosing

Propagate

then

Look-Up Table

Save the color image for future use by pulling down

FILE

and choosing

Save As

Click on the **TIFF** radio button to set the format, name the image ND930101.LUT, go to

Desktop | your hard drive | SEE Image | Images | Veg

and click **Save**.

Move the cursor up and down in the LUT window and notice the numbers that appear after “Value” in the Info window. You can see the range of NDVI values associated with each color.

You can change an image back to grayscale by pulling down

OPTION

and selecting

Grayscale

NOTE: When you have multiple images open on the desktop the colors of nonactive windows may change. The colors will be re-stored when you activate the window.

5.5.2 modifying the lut using the density slice tool

prerequisites:
steps 1–5.5.1

Another useful procedure to visualize distribution of NDVI values is density slicing, which uses a specialized LUT in which the user defines the range of NDVI values that will be highlighted by a single color.

Click inside the window with the ND930101 image to activate it. Double click the density slice tool in the tools window (you can also activate the density slice option by pulling down **OPTIONS** and selecting **Density Slice**).

To change the width of the density slice place the horizontal bar of the LUT pointer on the upper edge of the highlighted segment. Hold the mouse button and drag the upper edge to the desired location. You can do the same with the lower edge. Move the upper limit to 0.51 and the lower limit to 0.42.



If you want to change the color of the density slice, select the eyedropper tool and double click in the density slice region in the LUT window.

When the color picker window displays, choose the color you want to use to highlight the density slice region by clicking on it in the color wheel or adjusting the sliders on the color bars (whichever display your system shows).

Click OK.

You can always go back to the original DAAC NDVI color table by reselecting it from the **OPTIONS** menu.

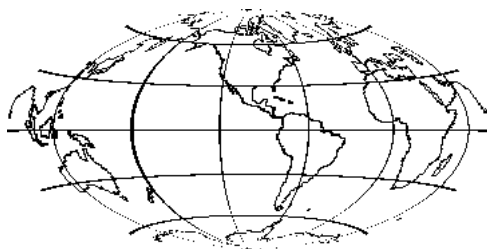


Map projections are used to represent a spherical object, Earth, on a flat surface like paper or a computer screen. The NDVI images are very distorted, which is obvious when one looks at the continental boundaries. The surface area of a pixel on the equator ($\sim 15400 \text{ km}^2$) is much greater than the surface area of a pixel near the poles ($\sim 100 \text{ km}^2$). We can minimize these distortions by using different map projections. SEE Image provides three: Hammer, Interrupted Goode Homolosine, and Orthographic.

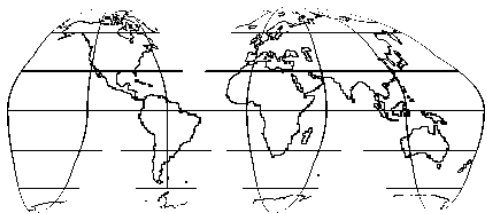
5.6 working with map projections

prerequisites:
steps 1–5.5.1

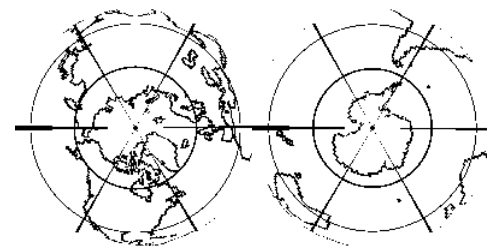
The **Hammer** projection is often used to display global data. Feature shapes are distorted, especially near the top and bottom edges of the projection, but their areas are not. In other words, each pixel in the image represents the same area. For that reason it is often an excellent choice for global analysis. Implementing the Hammer projection provides the option to define the center longitude for the projection, which allows you to control the portion of the globe that appears in the center of the image window.



The **Interrupted Goode Homolosine** projection is also an equal area projection but it differs from the Hammer projection in that the globe is not presented as a continuous feature. This projection is interrupted so that all of the land masses are continuous with the exception of Antarctica. This helps preserve the shape of land masses.



The **Orthographic** projection shows Earth as viewed from deep space. It's best used to view polar regions, which are often severely distorted by other projections. In an Orthographic polar projection, the area of greatest distortion occurs in the equatorial region. Both north and south polar aspects are available in SEE Image.



Make sure the SEE Image macros are loaded (Section 3). Activate the ND930101.LUT image that you created and saved in step 5.5 and pull down

SPECIAL

then select

ProjectHammer

Enter **ND930101.HAM** for the projected image name and click OK. Enter **–100** for a reference longitude, which corresponds to the center of the United States. The resulting image will be a football shape centered on the U.S.

You may simply close the file or save it as ND930101.HAM for future use by pulling down the **FILE** menu, choosing **Save As** and going to

Desktop | your hard drive | SEE Image | Images | Veg

Click **Save**.

Activate the ND930101.LUT image and pull down

SPECIAL

then select

ProjectGoode

Enter **ND930101.GH** and click OK. Close or save it as shown above.

Activate the GA781101.LUT image and pull down

SPECIAL

then select

ProjectPole

Enter 1 to select a northern polar projection and click OK.

Enter **ND930101.NP** and click OK. A square window will be created with the north polar projection of your image. Notice how only the northern hemisphere is shown. Close or save it as shown below.

For a southern projection, choose option 2 instead, and enter **ND930101.SP**, click OK, then pull down

FILE

select

Save As

click on the TIFF radio button, name the image, go to

Desktop | your hard drive | SEE Image | Images | Veg

and click Save. We'll be using it in the next section.

Sometimes it's necessary to identify the location of a specific pixel, for example, the pixel for Washington, DC. By converting latitude and longitude coordinates into image coordinates (X and Y) we can accomplish this.

DAAC AVHRR NDVI images are processed so that the northwest (upper left) corner of the image has the coordinates latitude=90°N, longitude=180°W. Moving in an easterly direction (to the right) each pixel represents a distance of 1°. Moving in a southerly (downward) direction, each pixel represents a distance of 1°. When locating a feature with known geographic coordinates we must first convert the latitude and longitude coordinates to X and Y image or pixel coordinates.

Lines of latitude run east to west around the globe. The best known line of latitude is the Equator, which has a latitude value of 0°. Lines

5.7 locating geographic coordinates

**prerequisites:
steps 1–5.5.1**

of longitude run north and south and always intersect at the poles. The 0° longitudinal line passes through Greenwich, England, which is the point of reference for global mean time. It is standard notation to make the lines of latitude south of the Equator negative and lines of longitude west of Greenwich negative; consequently, all locations in the continental US will have a **+latitude** and a **–longitude**.

Activate the ND930101.LUT image. Pull down

SPECIAL

and select

CalcLatLon

Enter 38.9 for latitude (click OK) and –77.0 for longitude (click OK). These are the coordinates for Washington, DC. In the Info window you will see the results of the calculation

X = 103 for longitude –77.0

and

Y = 51 for latitude 38.9

This pixel (X=103, Y=51) contains Washington, DC.

Move the cursor to this location in the image by monitoring the X and Y location in the Info window until X=103 and Y=51.

Now pull down

SPECIAL

and select

ShowLatLon

Move the cursor around the image again while watching the Info window. This gives you an interactive display of both the latitude-longitude values and the image coordinates of the pixel that's under your cursor. To stop the macro, click the mouse (sometimes the mouse button must be pressed and held for half a second to stop the macro).

NOTE: ShowLatLon will work on the global DAAC AVHRR NDVI projected and unprojected images. CalcLatLon will only work on global images without a map projection applied.

Find the approximate latitude and longitude for your home. Now go and check how close you are by looking it up in your atlas.

5.8 annotating and drawing on the image

prerequisites:
steps 1–5.5.1

Text and graphic objects such as points and lines can be added to an image. When adding graphics, it is important to remember that the graphic replaces the image values under it. One way to add text and graphics to an image without overwriting data is to create an image window larger than the current image then copy the image into the larger one. This adds a white window border where text and other items can be placed.

Pull down

FILE

and select

New

Enter **310** for the width, **250** for the height, and **New NDVI Image** for the title.

Click OK. This will create a blank image window.

Activate the **ND930101.LUT** image then pull down

EDIT

and select

Select All

followed by

EDIT

and choosing

Copy Selection

Click in the empty window to make it active and then pull down

EDIT

and choose

Paste

Now the image appears in the new window with a white border at the top and bottom of the image.

The image can be moved around inside the new window by clicking in the image while the “marching ants” surround it, holding the mouse button, and moving the mouse around the window.

NOTE: You can also use the *Cut* and *Paste* functions in the **EDIT** menu to move the image by first selecting the entire image and then cutting it.

If you move the image, center it in the window before continuing.

Text can now be placed in the white areas of the new image without changing any image values. Pull down

OPTIONS

and choose

Font

then select **Chicago** to change the font to Chicago. Pull down

OPTIONS

and choose

Size

then select **14** to change the font size to 14 points. Pull down

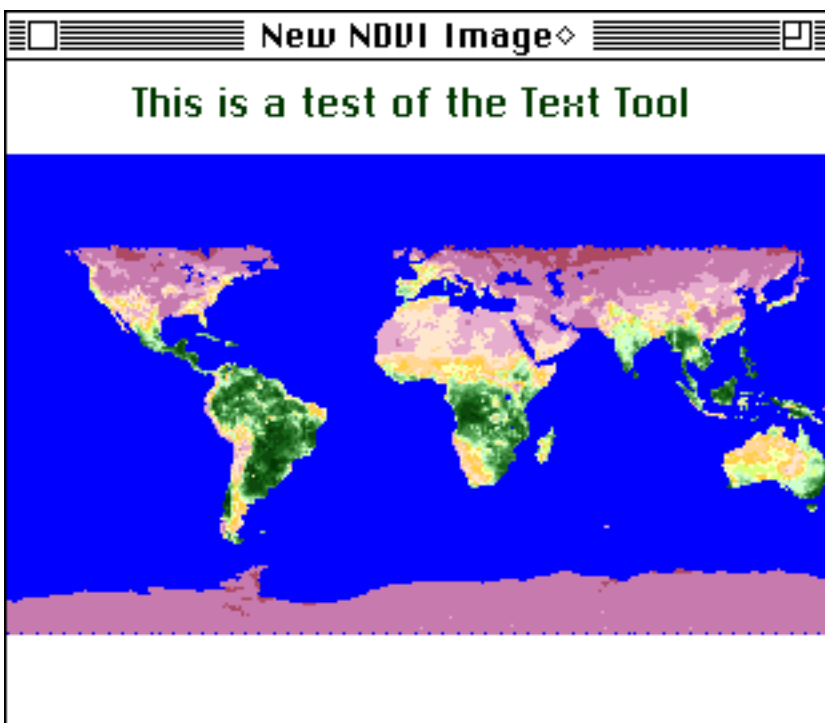
OPTIONS

and choose

Style

then select **Align Center** so the text will be centered on the cursor.

In the tools window, click on the big **A** to activate the text tool. Move the cursor to the center of the upper white block in the New NDVI Image and click once. Type “This is a test of the Text Tool.” As you type, the letters will appear in the white area. If you make a mistake, you can backspace or pull down **EDIT** and select **Undo** to start over.



This is what your new image will look like. In the lower white space, experiment with the other graphics tools as you did with the text tool.

pencil—Draws a freehand line on the image using the current foreground color. Line width is selected by clicking on one of the horizontal lines at the bottom of the Tools window. Holding the shift key while dragging forces a perfectly straight horizontal or vertical line.

eraser—Erases the area under the eraser by replacing image data with a background color. Click the eraser on a color in the LUT window to change the color of the background to show when an area is erased.

brush—To change the brush width double click on the paint brush. Click the brush on a color in the LUT window to change the foreground color that will show when an area is painted.

solid line—Draws a straight line on the image using the current foreground color. Line width is selected by clicking on one of the horizontal lines at the bottom of the Tools window. Hold the shift key to force the line to be exactly horizontal or vertical.

paint bucket—Floods areas having the same pixel value as the one you touch with the current foreground color. *Use this with care*, and remember that you can reverse this effect by *immediately* going to the

EDIT menu and choosing **Undo...** If you do anything else first, the Undo option will no longer be available for the paint bucket function you just did. It's a good idea to practice first using this tool on "scratch" images.

A—Places text characters in the window. Font, size, and style can be changed using the Options menu. Click the A on a color in the LUT window to change the foreground color for the text being written.

spray can—Draws random points using the current foreground color.

eyedropper—Selects the foreground color. To select a color move the eyedropper over the LUT window and click on the desired color.

lines of varying width—Selects the line width that the line tool will generate.



Close the New NDVI Image window.

It's a good idea to place an annotated color bar next to an image so you can easily see which vegetation values are associated with which colors. Pull down

FILE

and select

New

Enter **360** for the width, **250** for the height, and **New NDVI Image** for the title. This will create a blank image window.

Activate the **ND930101.LUT** image and pull down

EDIT

and select

Select All

followed by

EDIT

and choosing

Copy Selection

Activate the empty window, pull down

EDIT

and choose

Paste

and the image should appear in the middle of the new window with a white border at the top and bottom of the image.

From the right half of the Tools window, select the dashed rectangle tool. Draw a rectangle by placing the cursor at

X=20, Y=220

Click and hold the mouse button and drag down and across to **Width=300, Height=20** then release the mouse button. Pull down

SPECIAL

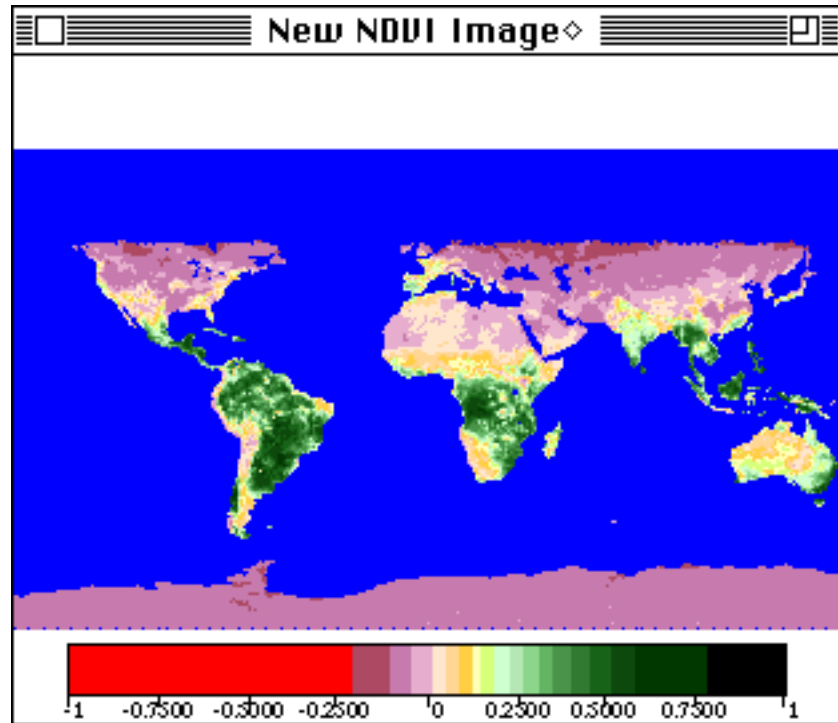
and select

MakeColorBar

Enter **-1** for the starting pixel. Click OK. Enter **.25** for the interval between numbers. Click OK. You should see an annotated color bar below the image.

5.9 creating an annotated color bar

prerequisites:
steps 1–5.5.1



Close the window.

5.10 selecting subregions for analysis

prerequisites:
steps 1–5.5.1

In some instances, it is necessary to perform a function on only a portion of an image. To do this, use one of the five selection tools illustrated by dashed lines on the right half of the Tools window.

Activate the **ND930101.LUT** image. Select the dashed rectangle tool. Move the cursor to the position

X=65, Y=35

click and hold the mouse button and drag toward the lower right corner of the image until Width=50 and Height=50 displays in the Info window. Release the mouse button. You'll see a square outlined with a flashing black and white "marching ants" line. Pull down

ANALYZE

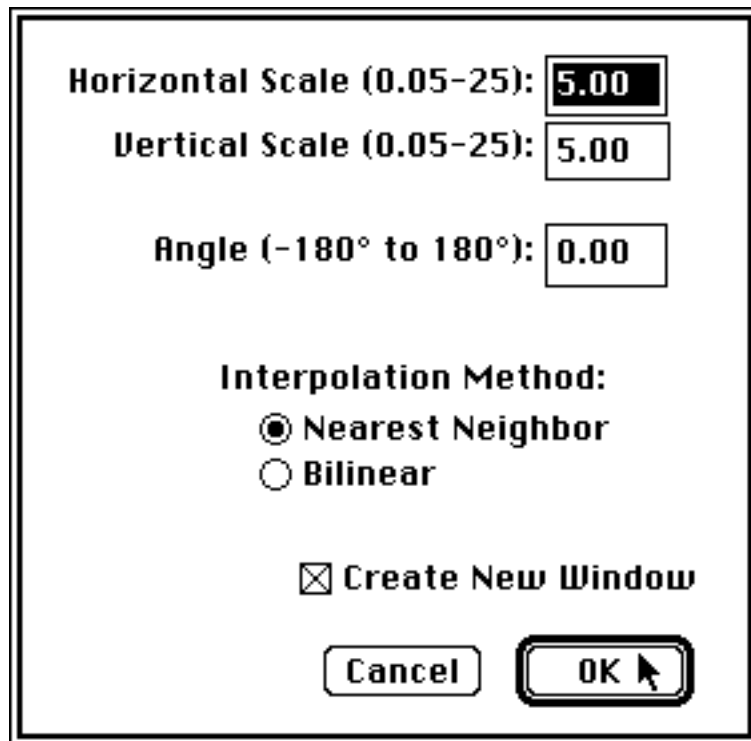
and choose

Show Histogram

to create a histogram of the pixels inside the square (see Section 7 for in-depth information on analysis techniques).

Experiment with these tools to see what they can do.

Set up the window as shown and click OK.



Close the window.

5.12 adding a title and scale bar to an image

prerequisites:
steps 1–5.5.1

When preparing an image for printing, it is often convenient to add a title and color bar to the image. The macro **MakeMap** is designed to do just that. With an image selected pull down

SPECIAL

and select

MakeMap

to display the five-part parameter window.

Enter **January 1993** in the space next to Title in the column Title Parameters.

Click OK to create a new image with a title and color bar.

Experiment by changing different settings in the parameter window.

TITLE PARAMETERS

title—The title for the new image window. The default is the title of the original image.

font—This is a pull-down menu. Click on the font you want used.

font size—The size of the font for the title.

attributes—This is a pull-down menu. Click on the desired font characteristics.

X-coord.reference—The left or right reference position for the title. If the font attribute *Align Center* is selected this will be the center position of the title. If the font attribute *Align Left* or *Align Right* is selected then this will be the left or right alignment mark for the title.

top Y-coord—The top or bottom reference point for the title.

UPPER LEFT IMAGE COORDINATES

left X-coord—The X coordinate for placement of the upper left corner of the image that will be pasted in the new window.

top Y-coord—The Y coordinate for placement of the upper left corner of the image that will be pasted in the new window.

STACK PROCESSING OPTIONS

available only if a stack is being processed (see Section 6)

use the slice title for each new image title—Select this if you want to use the slice title as the title in the new window.

use the title entered above for each new image title—Select this if you want to use the same title for each new window.

manually enter the title for each new image—Select this if you want to change the parameters for each slice.

LEGEND PARAMETERS

title—The title for the legend.

font—This is a drop-down menu. Click on the font to be used for the legend title and annotations.

font size—The size of the font for the legend title and annotations.

attributes—This is a drop-down menu. Click on the font characteristics to be used for the legend title and annotations.

X-coord. reference—The left or right reference position for the legend. If the font attribute *Align Center* is selected this will be the center position of the legend. If the font attribute *Align Left* or *Align Right* is selected then this will be the left or right alignment mark for the legend.

top Y-coord—The top or bottom reference point for the legend.

NEW WINDOW DIMENSIONS

width—The default value is 40 pixels wider than the original image.

height—The default value is 100 pixels higher than the original image.

5.13 printing an image

prerequisites:
steps 1–5.5.1

Pull down
FILE
and select
Print Image

To print a subsection of an image, pick a selection tool and mark out the area, then pull down
FILE
and select
Print Selection

SEE Image can save images in several formats. Pulling down

FILE

and selecting

Save

saves the image in its original format. If you want a different format, the **Save As** option will let you save the image in TIFF, PICT, MacPaint, PCS, or QuickTime, and the **Export** option lets you save a binary file with no header or trailer information.

Choose your output format depending on your intended use of the image. If it's important to preserve numeric data, **Save As** TIFF or **Export** with the *Raw Pixel Data* option. TIFF is recommended for saving single images and stacks. (See Section 6 for instruction on working with stacks.) TIFF is also the only format that will keep an image's metadata. If the image will not be used for quantitative work, PICT can be used. PICS and QuickTime can save stacks, but the titles of individual slices will be lost. Use MacPaint only to save black and white images.

For the exercises, we recommend that all images and stacks be saved in TIFF. Pull down

FILE

and select

Save As

and choose TIFF. Enter ND930101 for the name. In the file selection window go to

Desktop | your hard drive | SEE Image | Images | Veg

and click **Save**.

5.14 saving an image

prerequisites:
steps 1–5.5.1

6

working with multiple images

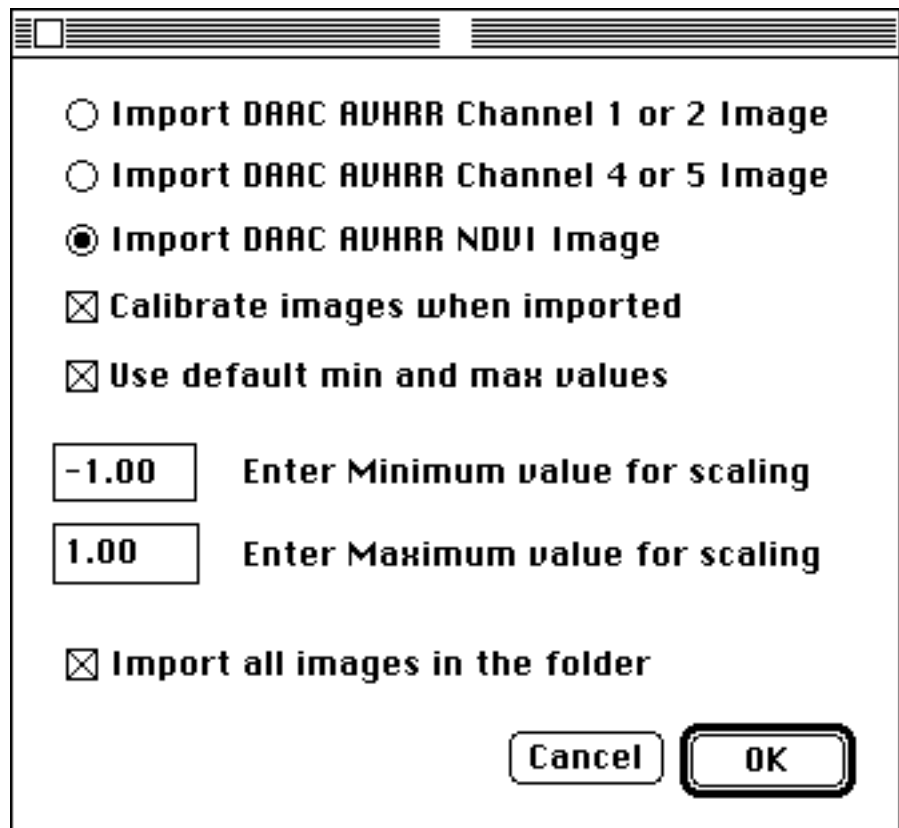
6.1

import sequential 10-day composite images for a year from a folder and save the stack

In some exercises it's necessary to import a series of images, such as all of the monthly composites for an entire year.

NOTE: Before you do this make sure you have enough memory to store the images, and close all open windows.

Under **FILE**, choose **Import DAAC AVHRR** and set up as shown.



Click **OK**. Go to

Desktop | your hard drive | SEE Image | Data | Veg | vgtutor | NDVI1993 | ND930101 and click **Open**.

Once the images are open, go to **STACKS** and choose **Windows to Stack**. Go to **FILE**, choose **Save As**, name the stack **NDVI93**, choose **TIFF**, then in the file selection window choose

Desktop | your hard drive | SEE Image | Images | Veg

and click **Save**. You'll be using this stack of images later.

Close the stack by clicking on the upper left square.

Under **FILE** choose **Open**.

In the file selection window, go to

Desktop | your hard drive | SEE Image | Images | Veg | NDVI93

and click **Open**.

Under **OPTIONS**, choose **Color Table** then **DAAC NDVI**.

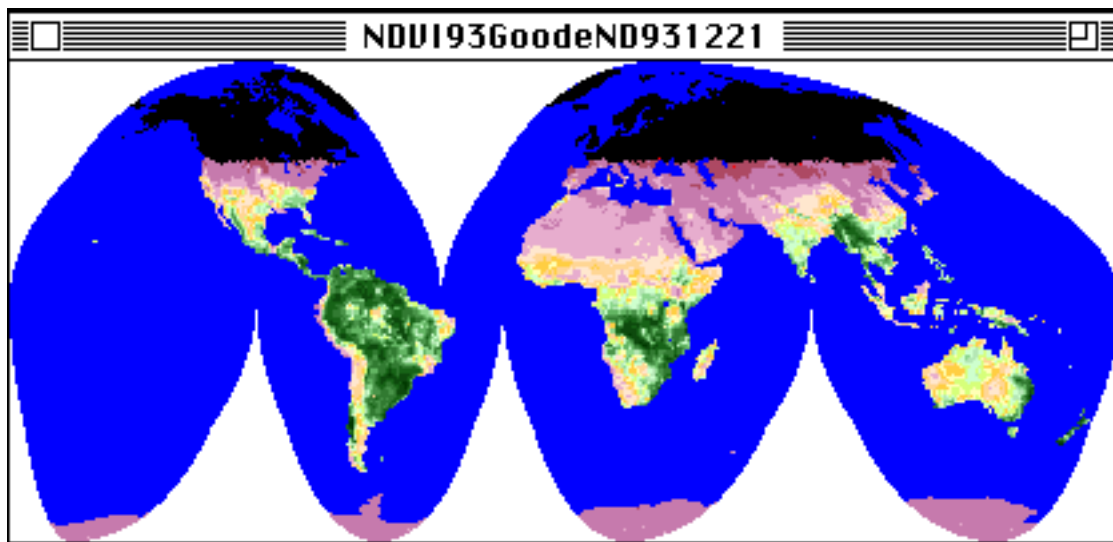
6.2
apply a lut to a stack
of images saved as
tiff

From the **SPECIAL** menu select **ProjectGoode**.

Enter **NDVI93Goode** for the name and click **OK**. A new stack of images will be created showing the Goode Homolosine projection.

NOTE: On a 68k Mac the first projection will take about 5 minutes to generate. The rest will process rapidly. You can monitor progress in the Info window.

6.3
change map
projections of a stack
of images



prerequisite:
step 6.2

Under **FILE** choose **Save As**. In the file selection window, go to

Desktop | your hard drive | SEE Image | Images | Veg

Keep the name **NDVI93Goode**, turn on **TIFF**, and click **Save**.

Close the stack called **NDVI93** before proceeding.

NOTE: If you want to try the other map projections you must start with the stack of unprojected images.

6.4 animating a stack of images

prerequisite:
step 6.2

Viewing several images one after the other is useful to see the change in a phenomenon over time. The **Animate** function in the **STACKS** menu enables this. Activate the stack **NDVI93**. Under **STACKS** select **Animate**.

You can speed up and slow down the movement with the number keys: the lower the number, the slower the speed. You can stop the animation by clicking anywhere on the desktop. To view the images in the stack one by one, press the period (.) key to look at the next image and the comma (,) key to view the previous one.

6.5 displaying multiple images using tile and montage

prerequisite:
step 6.4

Now we'll look at two more methods for viewing images: tiling, and making a montage. Tiling displays multiple images in miniwindows, placing as many as will fit on your screen. It doesn't scale the images, so you'll see only as much of each image as will fit in its miniwindow. This is a display-only function; the images remain as separate files.

From the **STACKS** menu, select **Stack to Windows**. From the **WINDOWS** menu, select **Tile Images**. Try using the hand tool to move the images around in their little windows.

Montage gives you control options for building a mosaic of images. It scales the images to fit your specifications so you'll see an entire image within each miniature window. It creates a new file that is a composite mosaic of your stack, which you can save if you wish.

From the **STACKS** menu, select **Windows to Stack**, then again from **STACKS**, select **Make Montage**. Try out the default settings and then experiment with changes. Click OK.

6.6 saving a stack for animation in other software

An image stack can be saved in either TIFF, PICS, or QuickTime format. PICS compresses a file so it will be smaller than its TIFF counterpart; however, TIFF is usually preferred since PICS can alter pixel values. After a stack has been saved, it can be viewed using QuickTime or other software capable of reading these formats. Only TIFF will retain the stack and slice names. PICS or QuickTime will display stack title and slice numbers.

You have already saved several stacks of images working through this section. Open your animation software and run it on one of those stacks.

There are several image analysis functions available in SEE Image. Some are designed to function with a single image and others require two images or a stack. These functions are located under the **ANALYZE** menu or as macros under **SPECIAL**.

Before we begin looking at the operation of specific analysis functions, let's get an overview of some of the entries under **ANALYZE** and **SPECIAL**.

Here are options under the **ANALYZE** menu that are used with AVHRR NDVI data.

Measure—Records measurements on an image that have been selected under Options to be displayed in a Results window.

Show Results—Displays the resulting measurements sequentially in the Results window.

Show Histogram—Generates a histogram for an image or selected region and displays results in a Histogram window.

Plot Profile—Generates a density profile plot for a selected line or rectangular region and displays the results in a Plot window.

Options—Generates a window that allows you to choose measurements that will be recorded when you select Measure as well as the number of, field length, and decimal places for measured values.

Set Scale—Performs spatial calibrations on an image so that length and area measurements are recorded in calibrated units.

Reset—Clears all previous measurements from the Results window.

NOTE: Unless you wish to keep measurements from a previous activity in the Results window, it is recommended that you reset that window before making measurements in a new activity. Measurements can be saved by activating the Results window and selecting **Save** or **Save As**. Navigate to the location where the measurements are to be stored, type in a file name, turn on the measurements radio button, and click **Save**.

7 image analysis of avhrr ndvi data with see image

prerequisites:
see image configured and
running with macros loaded

Reset the window by pulling down **ANALYZE** and choosing **Reset**. You may get the message

*You have measurements that have not been printed
or saved. These will be lost if you continue.*

Click **Continue** to clear the window.

SEE Image provides several macros, located under the **SPECIAL** menu, to provide image analysis capabilities. The macros that perform mathematical operations were developed because processed satellite image data often have pixels that have no-data values that should not be used in calculations.

CalcAvgStack—Calculates an average of each corresponding pixel in a stack to generate an average image.

CalcSDStack—Calculates a standard deviation for each corresponding pixel in a stack to generate a standard deviation image. Best used on subsets or equal area projections.

CalcCVStack—Calculates a coefficient of variation for each corresponding pixel in a stack to generate a coefficient of variation image. Best used on subsets or equal area projections.

CalcImageStats—Calculates the mean and standard deviation of all pixels on a single image. Best used on subsets or equal area projections.

Plot Temporal Profile—Plots values for a given pixel or region through two or more images in a stack as a function of stack image number.

CompositeDates—Creates a date index image, an array of numbers, that displays the date (or image's number) with the highest NDVI value for each pixel from the images in the stack to be composited.

CompositeStack—Creates a composite image from multiple images acquired at different times. This macro uses the date index image created by the CompositeDates macro.

7.1 measuring distance and area

In some instances it may be desirable to measure distance or area in an image. After projecting the images into an equal-area projection, such as the Hammer or Goode projection, we can make reliable area measurements on the images.

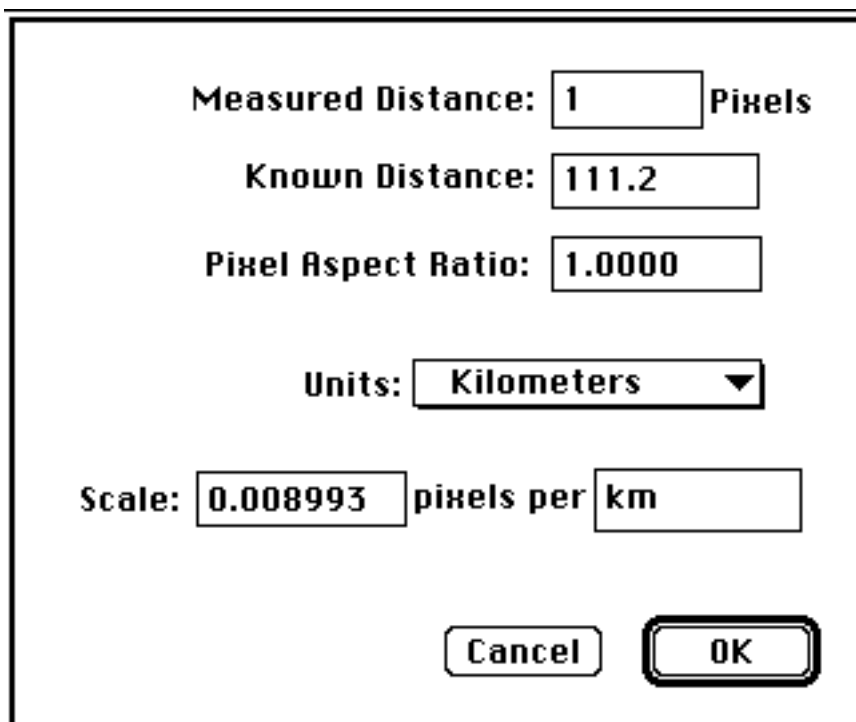
We'll use an image previously imported, modified, and saved in Section 5. Pull down **FILE** and choose **Open**. Go to

Desktop | your hard drive | SEE Image | Images | Veg | ND930101.LUT
and click **Open**.

Pull down **SPECIAL** and select **ProjectHammer**.

Enter **ND930101.HAM** for the projected image name and click OK.
For reference longitude, use the default setting.

Pull down **ANALYZE** and select **Set Scale**. Set up the window as shown.



Measured Distance: 1 Pixels

Known Distance: 111.2

Pixel Aspect Ratio: 1.0000

Units: Kilometers ▼

Scale: 0.008993 pixels per km

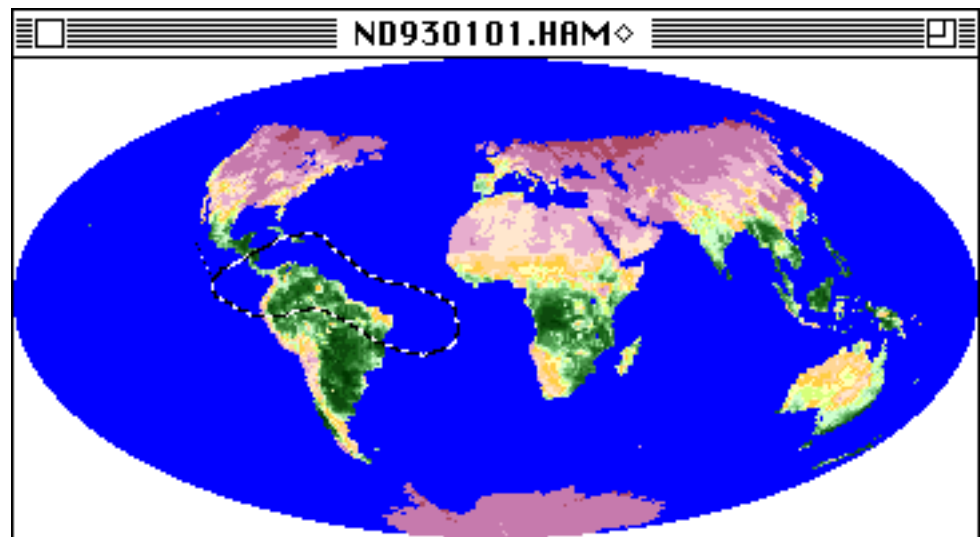
Cancel OK

Click OK.

Pull down **ANALYZE** and choose **Options**. Select only the **Area** and **Perimeter/Length** check boxes and turn off all others. Click OK to save the settings.

To make a distance measurement, select the dashed line tool from the Tools window. Let's try measuring the width of Earth by placing the cursor on the left side of the image at the equator. Click and hold the mouse button on one point on the image, drag to the right side of the image, then release. As you drag the mouse, you can view the distance (length) in the Info window. To view the results, pull down **ANALYZE** and select **Measure** followed by **ANALYZE** and **Show Results**. The measurements will display in the Results window.

To make an area measurement, select the dashed heart (or dashed rectangle) tool, click and hold the mouse button on the image, draw a polygon (or rectangle), and release. To measure and view area and perimeter, pull down **ANALYZE** and select **Measure** to register the measurement, which will appear in the Results window at the end of the list of measurements. (Perimeter measurements are listed in the Length column).



Close the ND930101.HAM image.

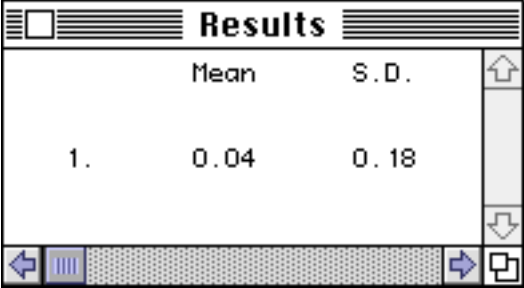
Clear the Results window by pulling down **ANALYZE** and selecting **Reset**.

When you want to calculate statistics, don't use images that have had overlays placed on them. As we explained before, overlays "replace" image pixels with black, temporarily altering the original image data you'll need for purposes of analysis.

You can calculate the mean and standard deviation of all pixel values in a single image using the **CalcImageStats** macro.

Activate or open ND930101.LUT by pulling down **FILE**, selecting **Open** and going to
Desktop | your hard drive | SEE Image | Images | Veg | ND930101.LUT
 and clicking **Open**.

Pull down **SPECIAL** and select **CalcImageStats**. The Results window will appear with the mean and standard deviation displayed. Close the Results window.



	Mean	S.D.
1.	0.04	0.18

A histogram provides a graphical view of the number of pixels for different NDVI levels. The histogram function in SEE Image is clean and simple. If a more elaborate histogram is needed you can output the histogram values to a text file in a format usable by many spreadsheet and graphing programs.

Activate or open ND930101.LUT by pulling down **FILE**, selecting **Open**, and going to
Desktop | your hard drive | SEE Image | Images | Veg | ND930101.LUT
 Click **Open**.

Pull down
ANALYZE
 and choose
Show Histogram

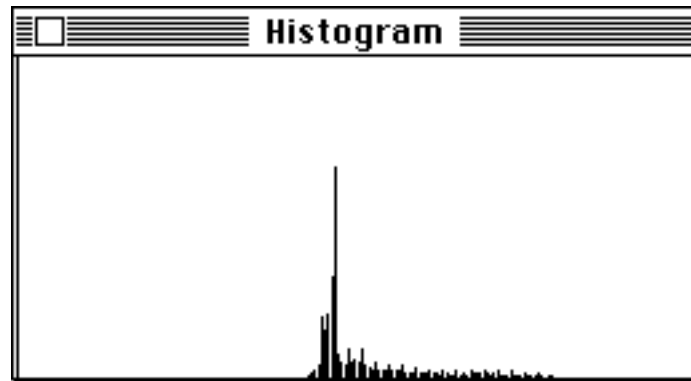
7.2 calculating image statistics

7.2.1 calculating an image mean and standard deviation

prerequisite:
step 7.1

7.2.2 creating a histogram of an image

prerequisite:
step 7.1



This will create a histogram of the image in another window showing the relative abundance of pixel values on the Y axis and the relative NDVI values on the X axis. The X axis is scaled so that the minimum NDVI value is on the left and the maximum value is on the right. The histogram can be examined with the cursor and the results are displayed in the Info window—the pixel value for the line under the cursor is displayed as **Level:** and the number of pixels in the image with that value is displayed as **Count.**

To print the histogram pull down **FILE** and select **Print Histogram.**

You can save the picture of the histogram as a black and white image but you will be unable to access the Level and Count values from the saved image. To save the histogram, activate the histogram window, pull down **EDIT** and select **Copy Histogram.** Then pull down **FILE** and choose **New.** Turn on the **Image Window** radio button. Set the width at **260** and the height at **125.** For the title, enter **ND930101.HP.** Select **EDIT** and **Paste** the histogram in the new window. Click on the desktop to secure it.

To export the histogram data pull down **FILE** and select **Export...** Turn on the **Histogram Values** radio button and enter **ND930101.HIS** for the name of the text file. This text file can be read into a graphing utility. It provides the number of pixels (the Y axis) for each SEE Image pixel value (0 - 255). To import these values into a spreadsheet, open the histogram file using a word processing package or as a Text file in SEE Image, and then select and copy all of the values in the file using **Select All** and **Copy** from the **EDIT** menu.

Next, start the spreadsheet program and in the first column enter the NDVI values that correspond to the values in the image (and the histogram window). Since SEE Image doesn't use pixel value 0, enter 0

in the first line of the column (first column). If the minimum and maximum values -1 and 1 were used when the image was imported, the second value in the column should be -1 .

Each successive value can be calculated by adding a constant to the previous value. The constant can be calculated by subtracting the minimum value from the maximum value and dividing the result by 253 ($2/253 = 0.00790513834$). Adding the constant should be done until the 255th line of the column has the value 1. This stepwise addition is usually done automatically with fill functions available in most spreadsheet programs. The last value (the 256 value) should be 0. In the second column, paste the contents of the text file using **Paste** from the **EDIT** menu. Now the spreadsheet is ready to be graphed following the instructions provided with your spreadsheet software.

Close the histogram and ND930101.HP windows.



Plotting a profile allows you to visualize the distribution of pixel values between two points on an image. This type of plot is useful for illustrating gradients in various phenomena such as land vegetation values.

Activate or open **ND930101.LUT** by pulling down **FILE**, selecting **Open**, and going to

Desktop | your hard drive | SEE Image | Images | Veg | ND930101LUT
Click **Open**. Select the profile tool and the thinnest line in the Tools window.

Click and hold the mouse button near the upper left corner of the image, drag to the lower right corner, then release.

The X axis represents the pixels under the line: X=0 represents the starting pixel and the last value represents the last pixel of the selection line. The Y axis represents pixel intensity. If you position the cursor on the plot line you can read the X, Y values for the point in the Info window. To save the values to a text file pull down **FILE** and select **Export** (you don't have to do this). The output text file will list the NDVI value for each pixel covered by the line.

7.3 plotting a profile

7.3.1 plotting a profile on a single image

prerequisite:
step 7.1

In the Tools window, select the thickest line and do the same steps you did before. This time the NDVI values inside the marching ants rectangle were averaged widthwise.

To save a picture of the plot pull down **EDIT** and choose **Copy Plot**, then pull down **FILE** and select **New**. Turn on the **Image Window** radio button. Set the width and height to accommodate the plot size (unlike the histogram, plot sizes vary). Type in a title and click OK. Pull down **EDIT** and choose **Paste**. The plot will be pasted into the new window (you don't have to do this).

Close the plot and ND930101.LUT windows.

7.3.2 plotting a profile through multiple images

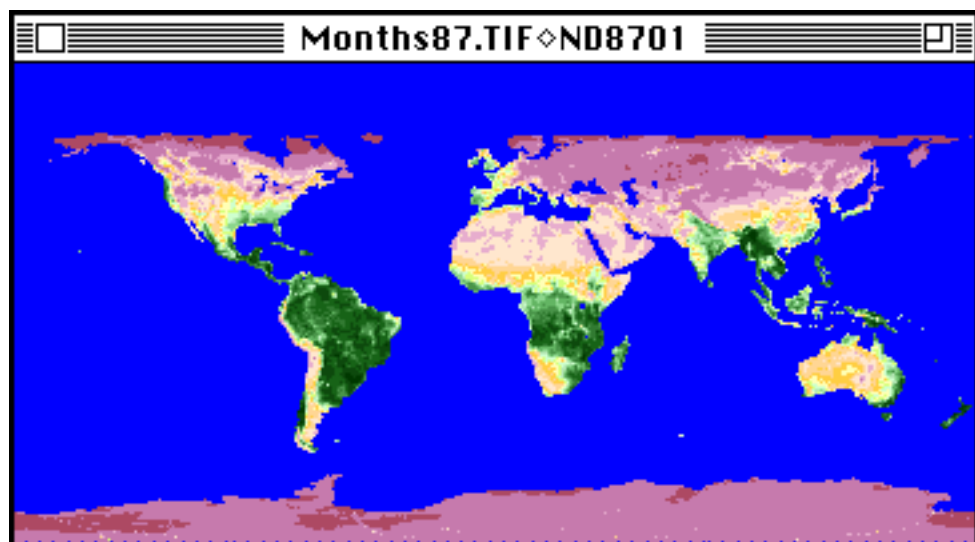
prerequisite:
step 7.2.2

A profile can plot pixel values for a given location through two or more images (slices) in a stack (or along the Z axis). This is good for viewing the change over time of a particular phenomenon. A profile of this type is a temporal profile.

Pull down **FILE** and select **Import DAAC AVHRR**. Select the radio button for importing NDVI, check "Calibrate images when imported," "Import all images in the folder," and "Use default min and max values." Click OK. Go to

Desktop | your hard drive | See Image | Data | Veg | vgtutor | NDVI1987 | ND8701
Click **Open**. Pull down **STACKS** and select **Windows to Stack**. Pull down **OPTIONS** and select **Color Tables** then **DAAC NDVI**. Pull down **FILE** and choose **Save As**. Go to

Desktop | your hard drive | See Image | Images | Veg
and save the file as **Months87.TIF** in TIFF format.





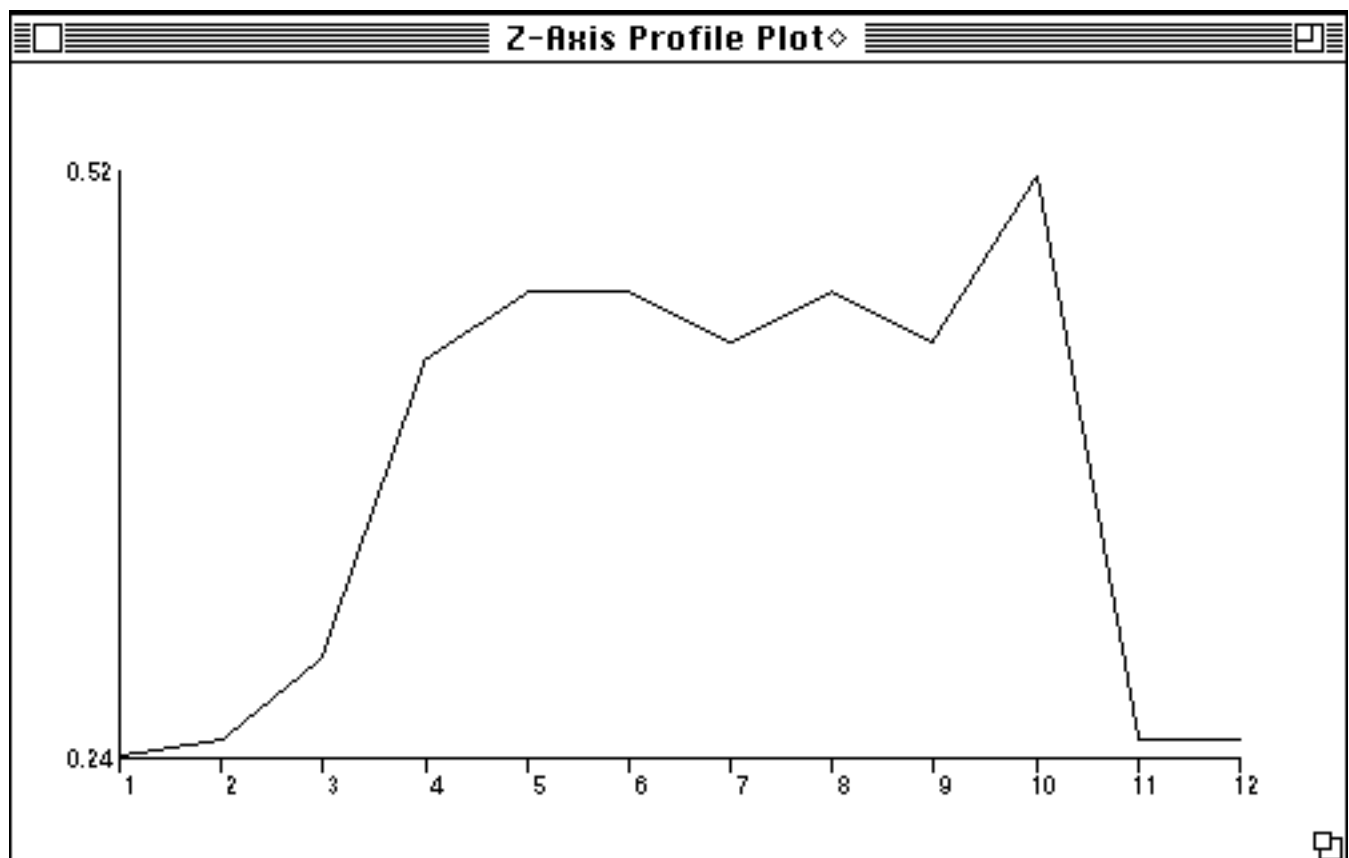
With the line selection tool and the thinnest line selected, place the cursor at $X = 100$ and $Y = 55$ and click the mouse. Be very careful not to wiggle it when you click.

Pull down **SPECIAL** and select **Plot Temporal Profile**.

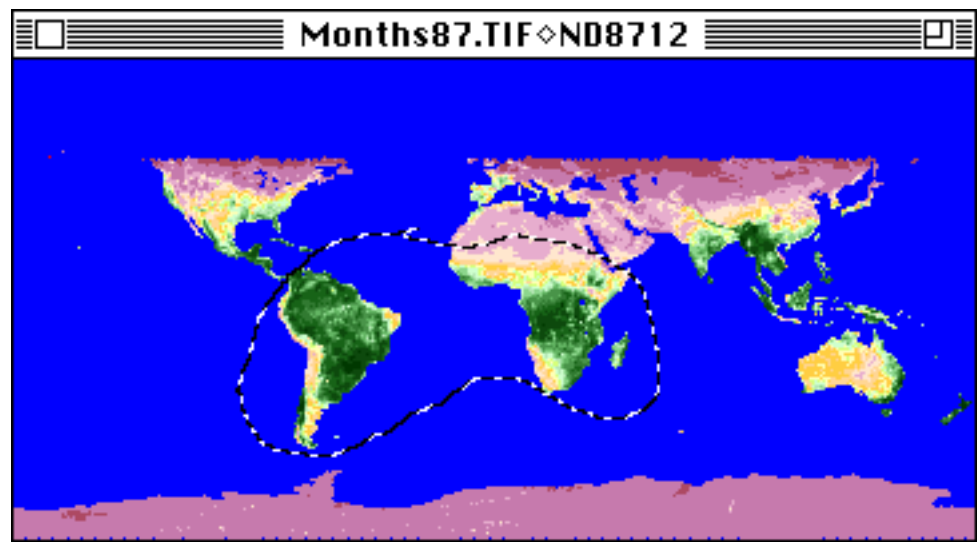
A window will appear showing the maximum value for the Y axis. Click OK. Another window with the minimum value for the Y axis will show up. Click OK.

In the plot that's produced the X axis represents the image in the stack and the Y axis represents the pixel value.

You can make a vertical profile using the average values for an area by marking off the area with one of the area selection tools. (For the next example, we selected the freeform rounded polygon [heart] tool.)

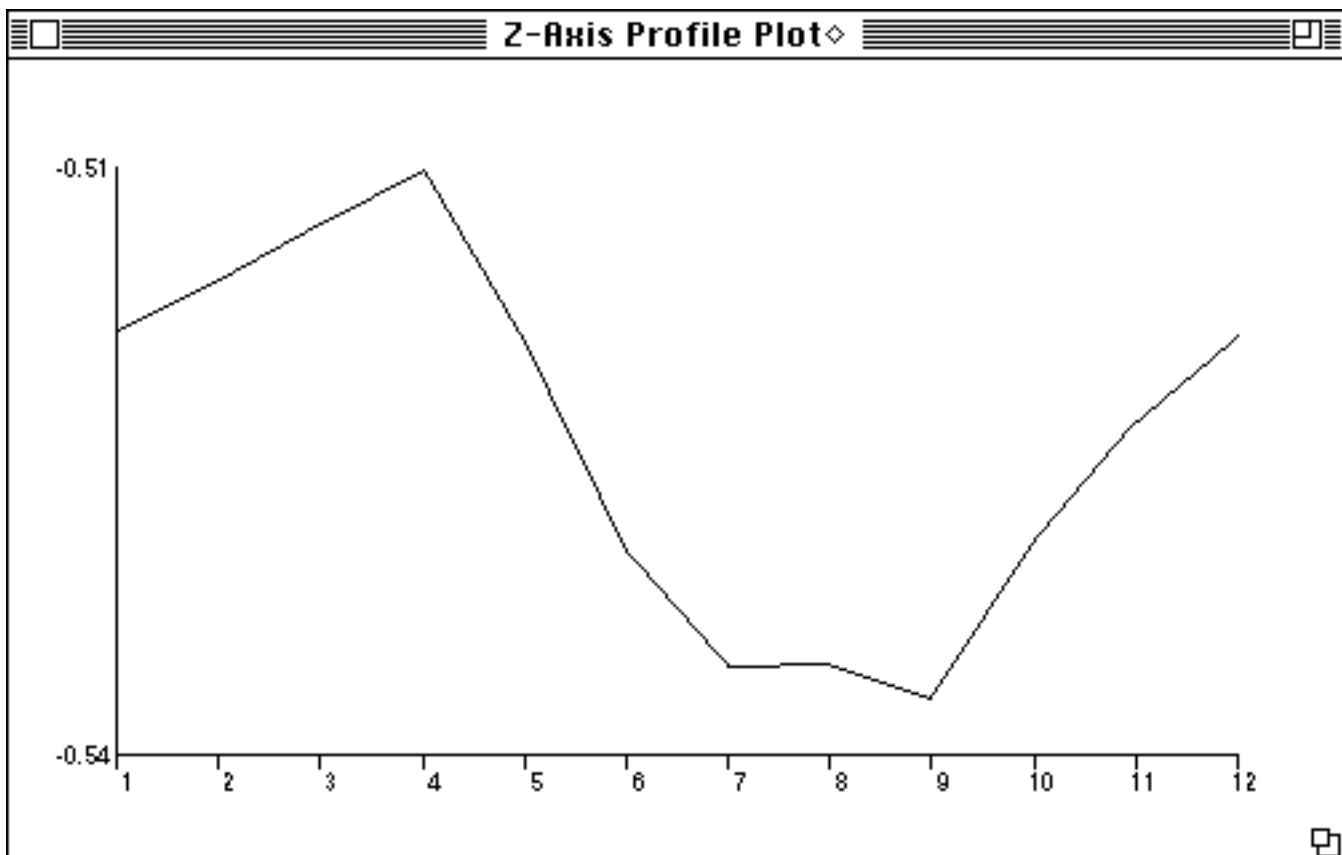


Pull down **SPECIAL** and select **Plot Temporal Profile**.



Example of an image area selected by the "heart" tool and its vertical profile

A window will appear showing the maximum value for the Y axis. Click OK. Another window with the minimum value for the Y axis will show up. Click OK. You have a vertical profile.



Close the Z-Axis Profile Plot window.

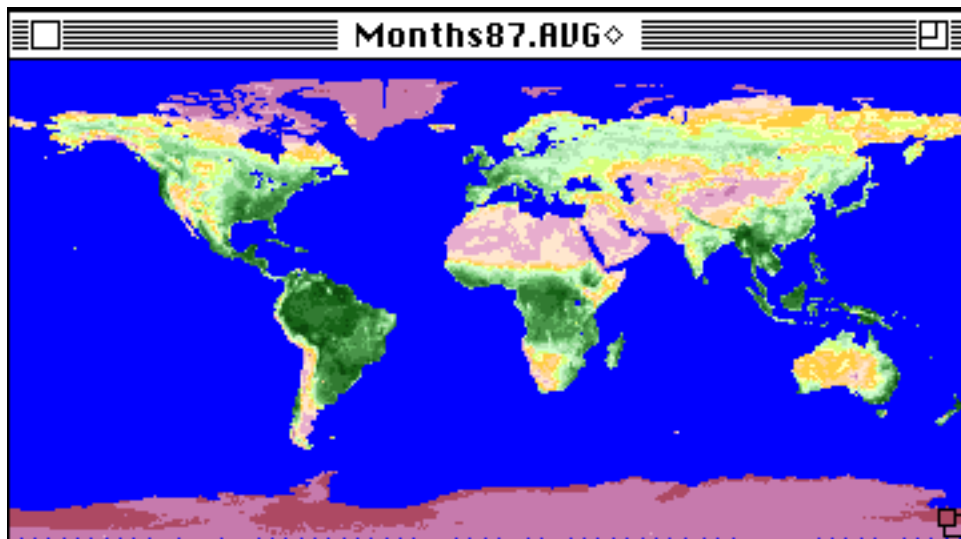
SEE Image has several macros that will allow you to generate statistics on a stack of images. It is recommended that you perform these functions on images that do not have an overlay to avoid loss of data.

Although there is a built-in function in NIH Image to average images in a stack, it treats “no data” pixels as if they were image data and that generates inaccurate averages. To get an accurate average image from a stack of images that contains no-data pixels, use the **CalcAvgStack** macro. The resulting image from this macro displays the average data value for each pixel.

Activate or open **Months87.TIF** by pulling down **FILE** and selecting **Open**. In the file selection window go to

Desktop | your hard drive | See Image | Images | Veg | Months87.TIF
and click **Open**.

Pull down **SPECIAL** and select **CalcAvgStack**. Enter **Months87.AVG** as the image title. Click OK. In the Info window you can monitor the progress of the calculation.



As you move the cursor over the image the average for each pixel will be displayed in the Info window.

Close **Months87.AVG**.

7.4 calculating stack statistics

7.4.1 calculating an average image from a stack

prerequisite:
step 7.3.2

7.4.2 calculating a standard deviation image from a stack

prerequisite:
step 7.3.2

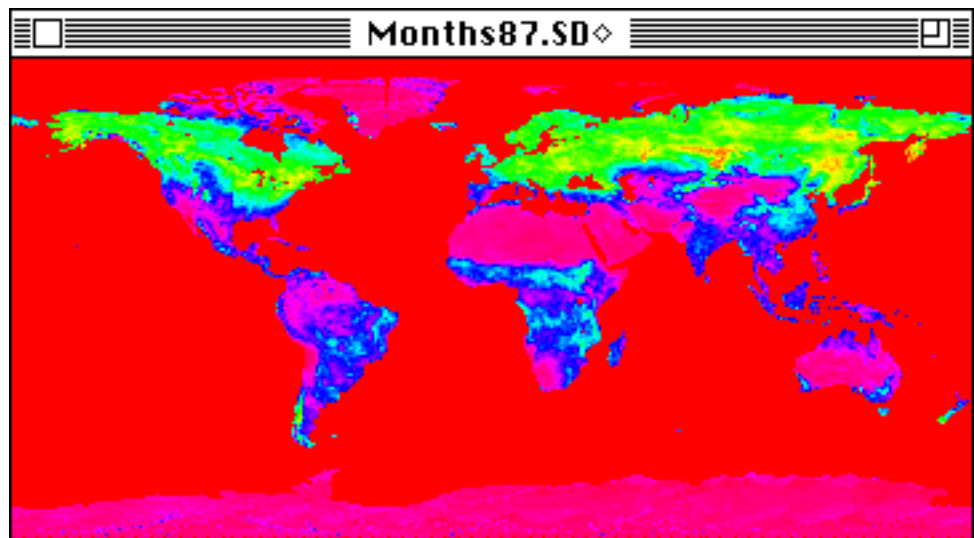
It may be useful to generate a standard deviation image from a stack to look for pixels with greater or lesser change. This can be accomplished using the **CalcSDStack** macro.

Activate or open **Months87.TIF** by pulling down **FILE** and selecting **Open**. In the file selection window go to

Desktop | your hard drive | See Image | Images | Veg | Months87.TIF
and click **Open**.

Pull down **SPECIAL** and select **CalcSDStack**. Enter **Months87.SD** as the image title and click **OK**. In the Info window you can monitor the progress of the calculation.

Pull down **OPTIONS**, select **Color Tables**, then **Spectrum**.



As you move the cursor over the image, the standard deviation value for each pixel will be displayed in the Info window.

Close **Months87.SD**.

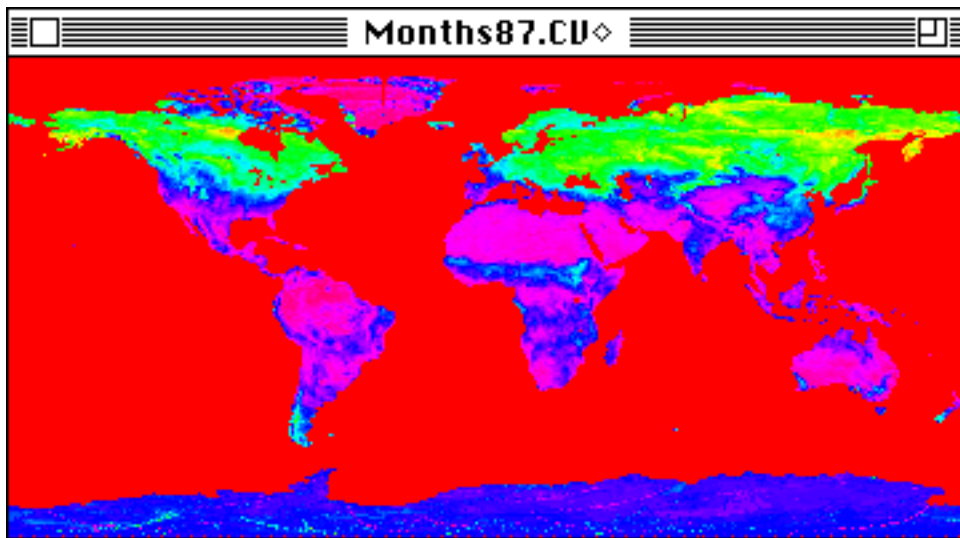
The coefficient of variation for a pixel is the standard deviation of that pixel divided by the mean. You can compute a coefficient of variation image by using the macro **CalcCVStack**.

Activate or open **Months87.TIF** by pulling down **FILE** and selecting **Open**. In the file selection window go to

Desktop | your hard drive | See Image | Images | Veg | Months87.TIF
and click **Open**.

Pull down **SPECIAL** and select **CalcCVStack**. Enter **Months87.CV** as the image title and click **OK**. You can monitor the progress of the calculation in the Info window.

Pull down **OPTIONS**, select **Color Tables**, then **Spectrum**.



As you move the cursor over the resulting image, the Info window will display the coefficient of variation value for each pixel.

Close all image windows.

7.4.3 calculating a coefficient of variation image from a stack

prerequisite:
step 7.3.2

7.5 using math operations on images

prerequisite: step 7.1

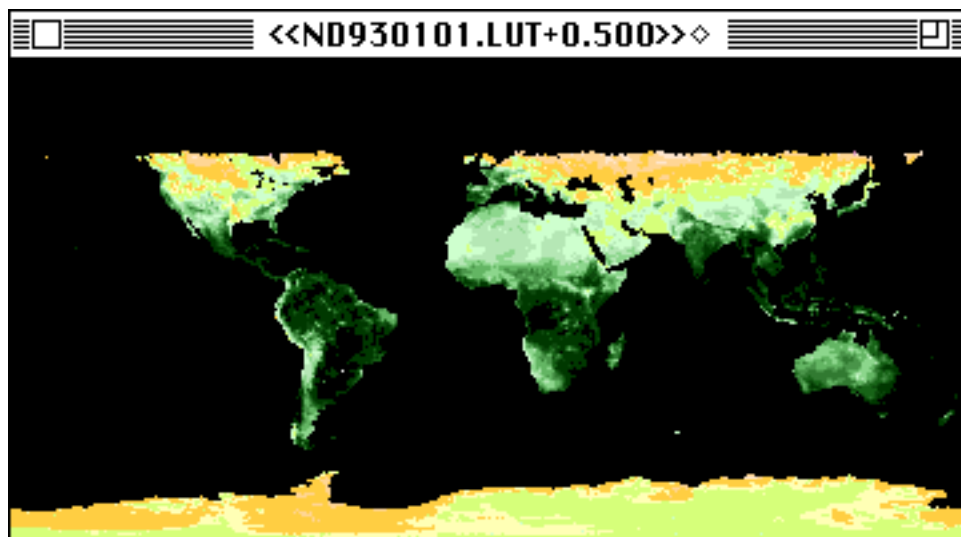
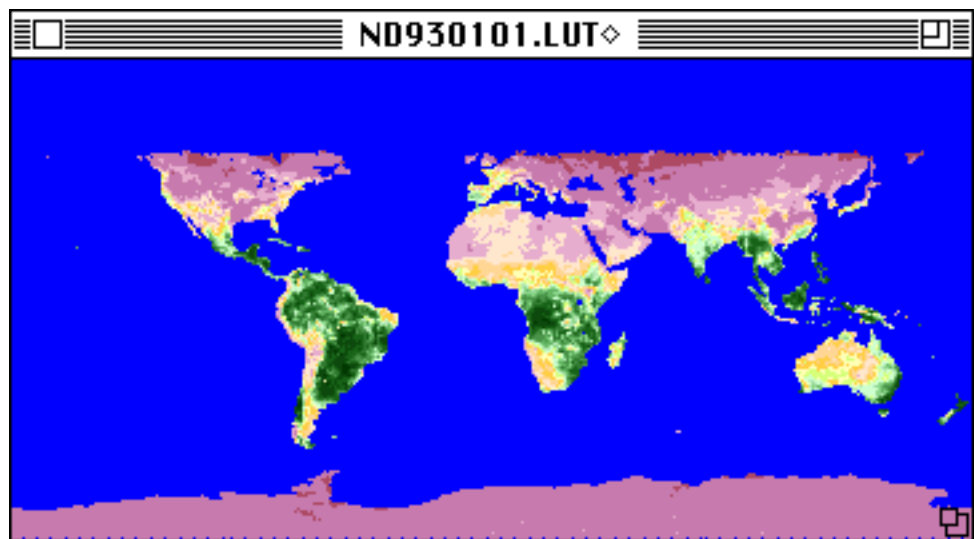
Image math functions perform a range of mathematical operations that can be performed using one image and a constant or two images and constants. Although most image math in our exercises is performed using macros, this is an important functionality for image analysis. For example, image math functions can be used to calculate an image that represents the average of several images or to compare images to highlight certain phenomena such as seasonal changes in land vegetation.

We'll perform a mathematical operation between an image and a constant. Pull down **FILE**, select **Open**, and go to

Desktop | your hard drive | See Image | Images | Veg | ND930101.LUT

click **Open**, then pull down **PROCESS** and select **Arithmetic** followed by **Add**. Enter **0.5** as the constant to add. Make sure there is an **X** in the **Real Result** box, then click **OK**. The resulting image will be similar to the original image except the NDVI values will be greater by 0.5.

Original image.



*Image with 0.5 added
to the NDVI values.*

One technique to visualize the difference between two images is to subtract them. When we subtract two images the result is an image where pixel values >0 indicate areas where the first image had a higher value, and pixel values <0 indicate areas where the second image had a higher value. The further the resulting value is from 0, the greater the difference between the two images.

Pull down **FILE**, select **DAAC AVHRR**, and select the radio button for importing NDVI. Check the “Calibrate images when imported” and “Use default min and max values” check boxes. Make sure the “Import all images in the folder” check box is **not** checked. Click OK.

Go to

Desktop | your hard drive | SEE Image | Data | Veg | vgtutor | NDVI1993 | ND930101 and click **Open**.

Repeat the file opening procedure, going to

Desktop | your hard drive | SEE Image | Data | Veg | vgtutor | NDVI1993 | ND930701 instead. Click **Open**.

Pull down **PROCESS** and select **Image Math** to activate the Image Calculator, which is used to perform math operations between two images. In this case we want to subtract the **ND930101** image from the **ND930701** image. Set up the window as shown. Click OK.

We clicked in the Real Result box because the resulting image pixel values will be outside the 1–254 range.

Image Calculator

ND930701

-

ND930101

X 1.0000

+ 0.00

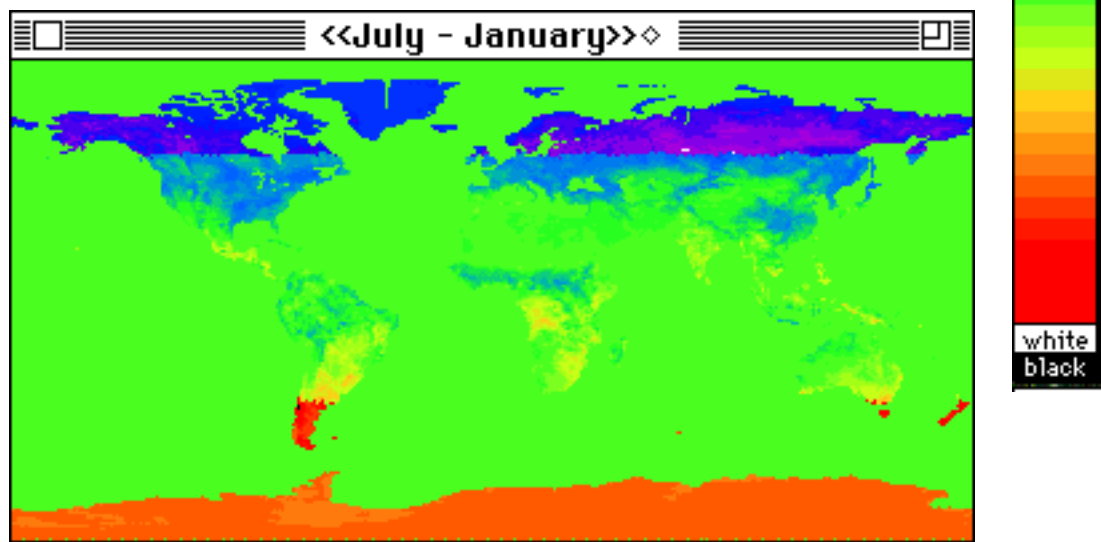
= July - January

☒ Real Result

Cancel OK

Pull down **OPTIONS** and choose **Color Tables**, then select **32 Colors** to color the resulting image.

In the resulting image yellow through red indicate areas where NDVI values were higher in the ND930101 image, with the red representing a greater difference. The green colors indicate areas where NDVI values were similar in both images. Blue and purple indicate areas that had higher NDVI values in the ND930701 image.

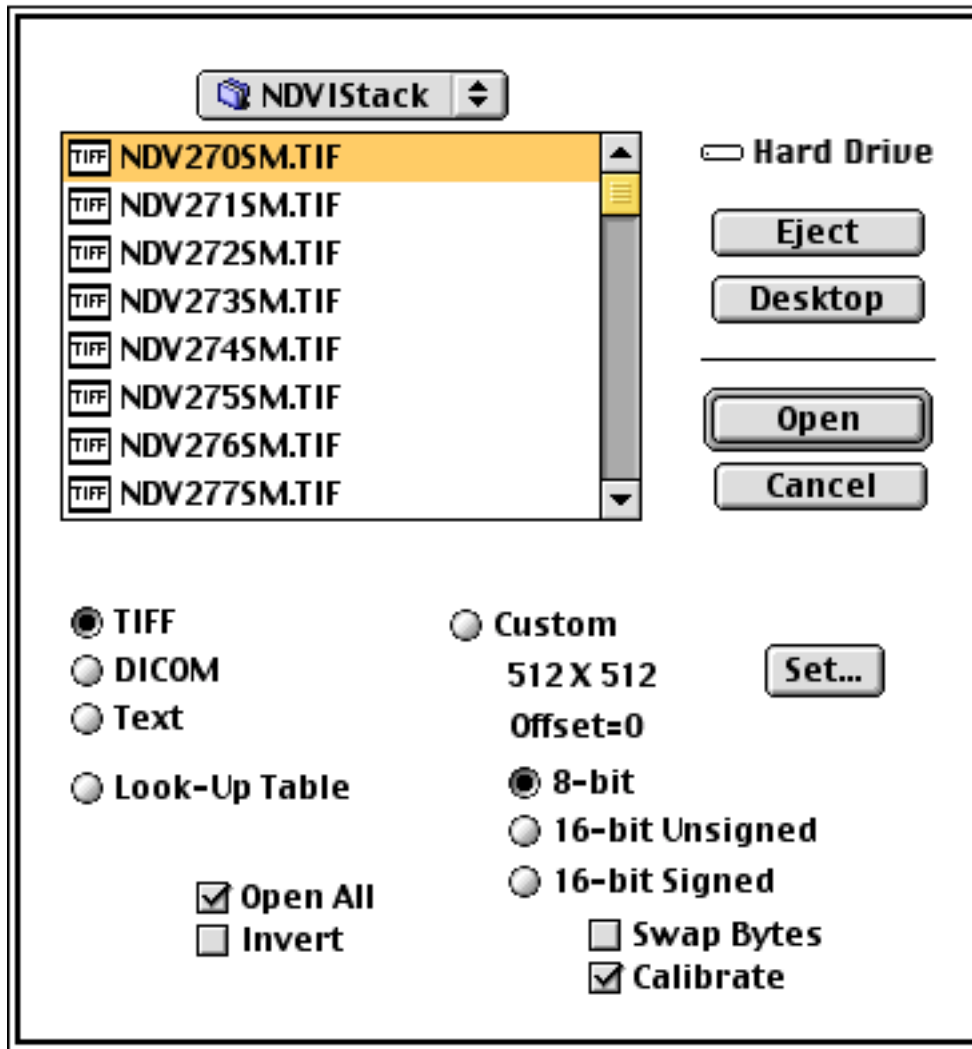


Close all image windows when finished.

Creating a composite image from several different images of varying dates is a common technique to reduce geometric and atmospheric distortions inherent in satellite imagery.

First, close any open images. Then pull down **FILE**, select **Import**, go to **Desktop | your hard drive | SEE Image | Data | Veg | vgtutor | NDVISTack | NDV270SM.TIF** and set up the radio buttons and check boxes as shown.

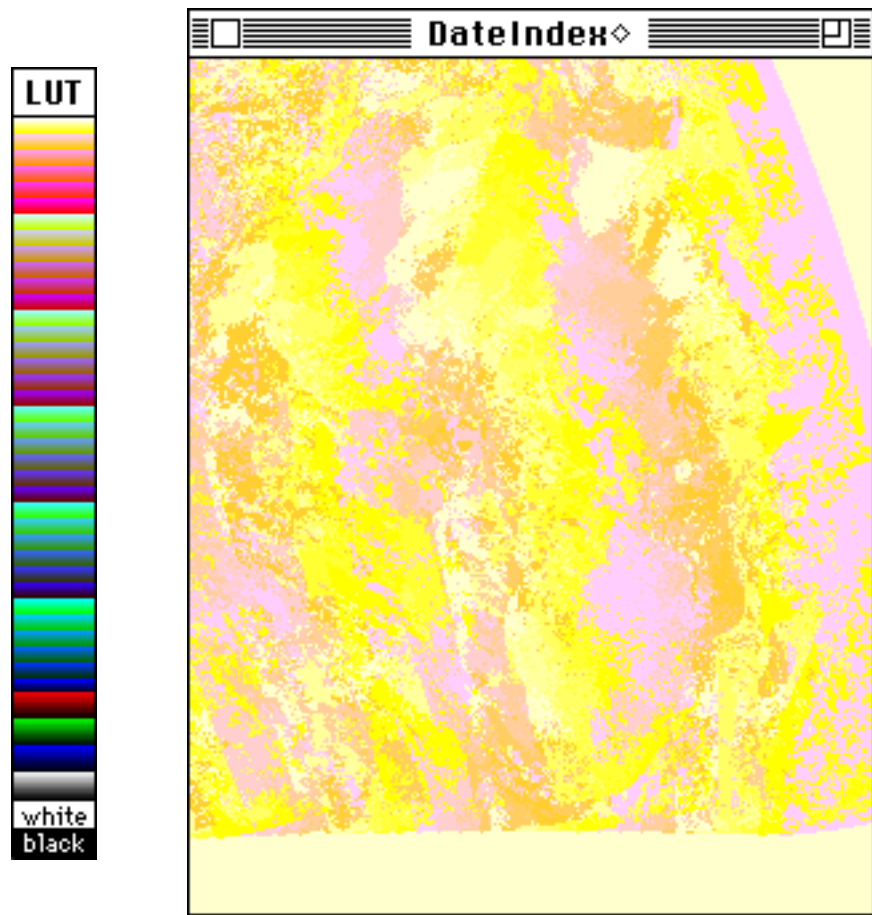
7.6 creating a multirate composite image



Click **Open**. Then pull down **STACKS** and choose **Windows to Stack**.

Pull down **SPECIAL**, choose **CompositeDates**, and enter **DateIndex** in the box under "Enter date-image title." Click **OK**.

The **CompositeDates** macro looks at all 10 slices in the stack a pixel at a time, determines which slice has the highest NDVI value for each pixel, and records those slice numbers in a file. The resulting image will appear white because the pixel values are all low. Pull down **OPTIONS** and select **Color Tables** and **System** so you can see the data value distribution.



Pull down **FILE**, choose **Save As**, and click the TIFF radio button. Go to **Desktop | your hard drive | SEE Image | Images | Veg** and enter **DateIndex.TIF** in the title box. Click OK.

Activate the **NDV270SM – NDV279SM** stack. Pull down **SPECIAL**, choose **CompositeStack**, and enter **NDVIComposite** in the box under “Enter composited image title.” Click OK.

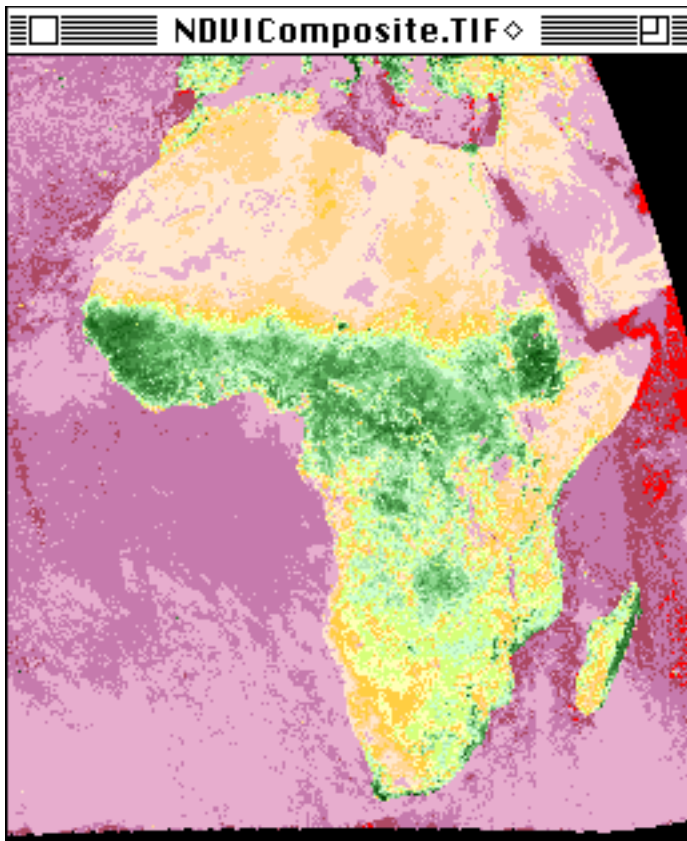
When the file selection window appears go to **Desktop | your hard drive | SEE Image | Images | Veg | DateIndex.TIF**. Click **Open**.

Pull down **OPTIONS** and select **Color Tables** then **DAAC NDVI** to color the image.

Now you'll see an image that contains the best quality pixels from a 10-day NDVI image stack.

Pull down **FILE** and choose **Save As**. Click the TIFF radio button and go to

Desktop | your hard drive | SEE Image | Images | Veg
naming the image NDVIComposite.TIF. Click OK.



You can also use this technique along with the date index image you generated to create composite images of each of the five AVHRR image channels you'll learn about in the exercises.

Close all images when finished.