

exercise 1

investigating the characteristics of the global monthly sea surface temperature data set for 1982–1998

In this activity you will learn how the global sea surface temperature (SST) data files were named, how to open and display the data files as images using *SEE Image* (a modification of *NIH Image* for Macintosh computers), and how to apply a color table to the images. You will also learn how to convert an image's pixel values to actual temperatures in degrees Celsius.

Before working with any data it is important to understand their characteristics. A knowledge of the data type, data source, geophysical units, file naming convention, and temporal and spatial resolution are critical to ensure correct scientific interpretation. Equally important is the software tool available for displaying and analyzing these data—you will be using *SEE Image*, a modification of *NIH Image* for Macintosh computers that was developed especially for the Studying Earth's Environment From Space educational modules.

characteristics of the global monthly sea surface temperature data set for 1982–1998

Geophysical Measurement:	Sea Surface Temperature
Units of Measurement:	Degrees Celsius
Data Source:	Satellites (NOAA AVHRR) and <i>in situ</i> buoys
Temporal Resolution:	Monthly averages
Spatial Resolution:	1° latitude x 1° longitude
Software application:	<i>See Image</i>

exploring global, monthly sea surface temperature

There are three types of SST data files provided.

- Global, monthly-average SST files for 1982–1998 (202)
- Global, monthly, climatological SST files (12)
- Regional, high resolution, monthly-average SST data sets for four regions for 1988–1993

The first two data sets contain monthly-average values of SST in units of degrees Celsius over the entire planet, excluding land. The spatial resolution of these images is approximately 1° latitude by 1° longitude per pixel. This means that each pixel in the image has the equivalent geographic scale of about 1° latitude by 1° longitude. The monthly climatological SST data set is provided for use in Exercise 4 and was obtained by averaging the monthly, global SST data for the period 1982–1998. The regional, high resolution SST data sets are also monthly averaged, however the spatial resolution is about 9 km by 9 km per pixel. High resolution regional data exist for the following areas.

- Northeast Pacific Ocean
- Northwest Atlantic Ocean (including the Gulf Stream)
- Gulf of Mexico
- Indian Ocean (including the Arabian Sea)

For the three SST data types described above, the file names are constructed as follows:

Global, monthly-average SST files for 1982–1998

gmYYMMt.tif

where

YY = last two digits of the year (from 82–98)

MM = two digits representing the month (from 01–12) where 01=January, 02=February, etc.

Global, monthly climatological sst files

glocMMt.tif

where

MM = two digits representing the month (from 01–12) over which the climatological average was computed

Regional, high resolution, monthly-average sst data sets for four regions for 1988–1993

RRRYMMt.tif

where

RRR= nep for Northeast Pacific

nwa for Northwest Atlantic

gom for Gulf of Mexico

ind for Indian Ocean

YY = last two digits of the year (from 88–93)

MM = two digits representing the month (from 01–12) where 01=January, 02=February, etc.

opening and displaying a global sst data image

Because some of the images we will be using to begin this exercise are large, it may be necessary to change the clipboard size.

Do A and B now.

A

set up see image

1 — Start *SEE Image* by double clicking on its icon.



SEE Image 2.56/ppc

2 — Select 'Options/Preferences.'

3 — Make sure the Undo & Clipboard Buffer Size is set to >500 k, and that "Invert Y-Coordinates" is NOT selected. Click OK.

4 — Click OK again to close the message box you'll see.

5 — Select 'File/Record Preferences.'

6 — Select 'File/Quit' to exit *SEE Image*.

7 — Restart *SEE Image* by double clicking on its icon.

8 — Select 'Special/Load Macros.' Go to Desktop | HD | SEE Image | Macros | SEE_macros. Click Open.

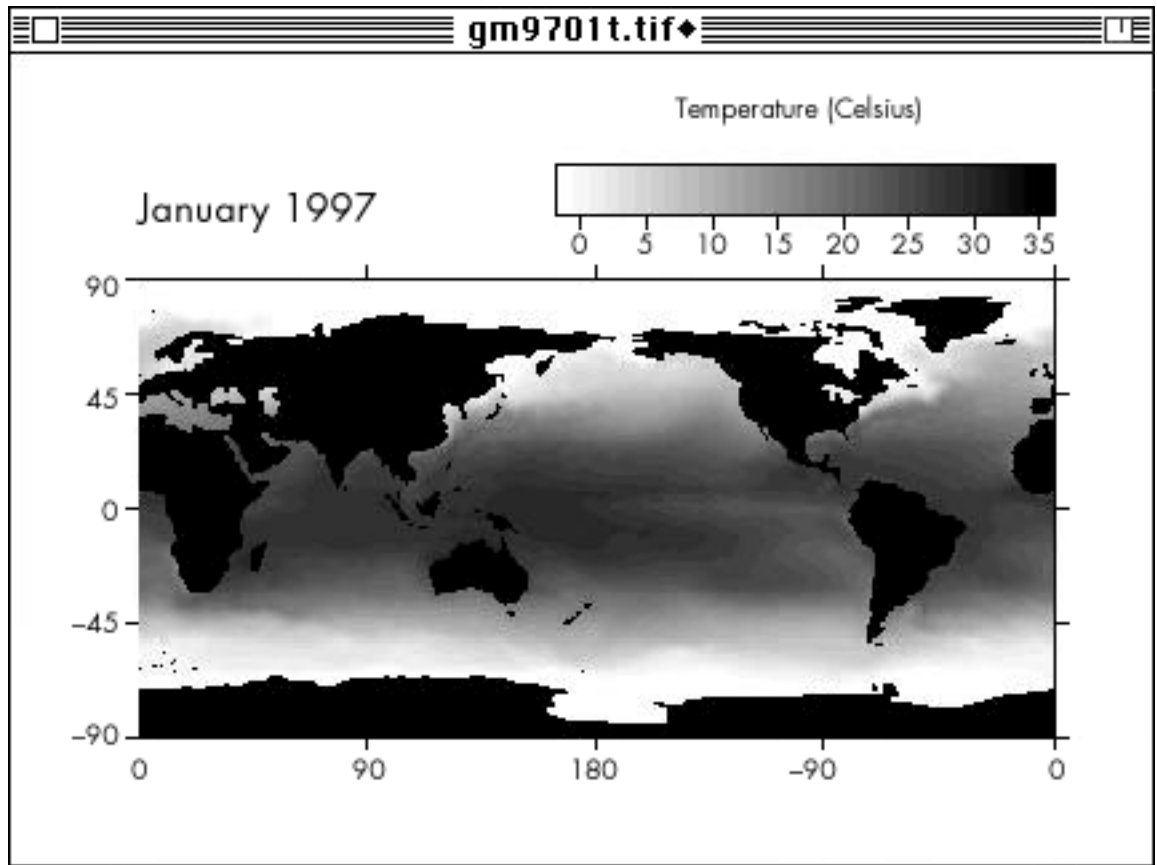
B

open a data file

1 — Select 'File/Import.'

2 — Go to Desktop | HD | SEE Image | Data | Oceans | sstex1. Double click on the folder of either year then click once on any file and click Open.

You should see an image on your screen that looks like a rectangular map of Earth in shades of gray.



This image is a monthly average SST image for January 1997.

1. Write down the name of the file you imported.

2. Interpret the file name and record the year and month of the SST image you displayed.

Month _____ Year _____

adding color to the image

To better distinguish differences in SST of the oceans we can apply color to the image using a color table, also called a color look-up table (LUT), that assigns SST values to each color.

C

color your image

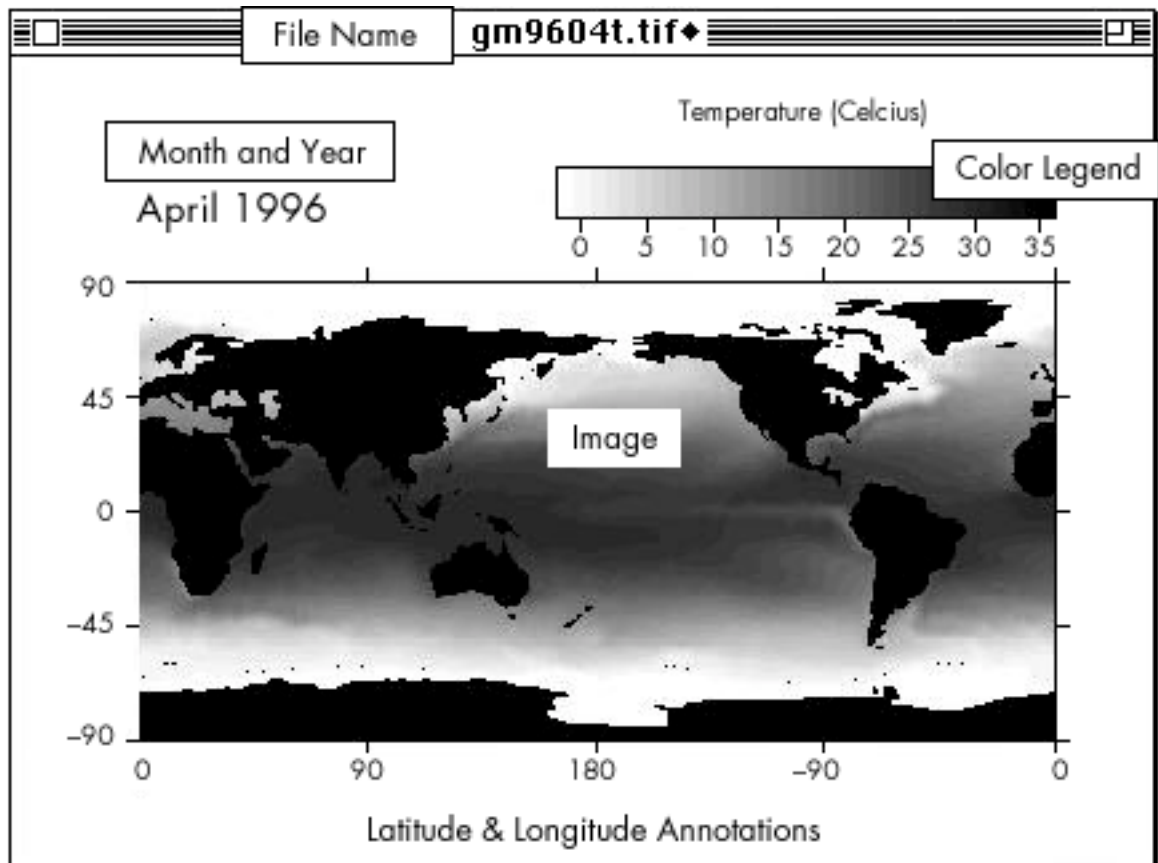
1—Select 'Options/Color Tables/SST'.

Do C now.

The image should now be displayed in color and the LUT window will display the color range used. Notice that the LUT window corresponds to the color legend on the image. This legend associates the color of the pixels in the image to their corresponding SST.

understanding display windows and images

If you do not have a global SST image open on your screen, open one now. You do not need to apply color to this image. This is called the Display Window. Notice the elements that make it up.



Across the top of the Display Window the **file name** is displayed. In the top, right corner there is a **color legend**, labeled with the units of the data. To the left of the color legend, the **month and year** of the data are displayed. The image itself has a thin black border around it and tick marks indicating **latitude and longitude**. In these exercises, “the image” refers to only the information within the latitude-longitude annotations. “Display Window” refers to the entire figure including the color legend and annotations. In most of these exercises, you will be working with only the image itself, not the entire Display Window.

studying how the images are organized geographically

Now study the latitude and longitude annotations on the image. North latitudes are always positive and south latitudes are always negative. These images are centered on the Equator (0° latitude) and the International Date Line (180° longitude). Longitudes are referenced to the Greenwich Meridian (0° longitude) with longitudes to the east of 0° being positive and longitudes to the west being negative. Answer some general questions to get familiar with the geographic layout of the image.

D

pick your spot

1—Select the Rectangular Selection Tool



from the Tools Window so your cursor will look like a crosshair. Place your cursor on the approximate geographic center of the image.

2—Move your cursor up to the Color Legend and slide it along the color bar until you observe the same value in the Info Window as you recorded above.

Do D1 now.

3. Record the value from the Info Window at this location.

Value: _____

Do D2 now.

4a. Read the SST in degrees Celsius from the color legend and record it below.

SST in degrees C: _____

4b. Similarly, locate and record below the SST at the intersection of the Greenwich Meridian and the Equator.

SST in degrees C: _____

exploring oceanography using satellite data—computer lab exercises

E**add labels**

1—Select the Text Tool



and label north and south latitudes and east and west longitudes directly on the image by typing the words “north,” “south,” “east,” and “west” in the appropriate locations.

2—To select the color of the text to be white, click once on the Eye Dropper.



Move the Eye Dropper into the LUT window and click once toward the bottom where it says “white.”

3—Click once on the Text Tool and you can begin typing right on the image.

Do E now.

Later on, in the section on the relationship between pixel value and SST, we will examine the relationship between the Value (also called a “pixel value”) and the SST in degrees Celsius. For now, just familiarize yourself with the various *SEE Image* windows and with reading the SST from the color legend.

F**identify dx and dy values**

1—Select the Line Drawing Tool



and draw a horizontal line from the left edge of the image (not the Display Window) to the right edge (hold down the shift key while dragging to force a straight line). While you draw the line the Info Window displays DX (the change in the X direction) and DY (the change in the Y direction). Once you’ve drawn the line all the way across the image from west to east, *but before you release the mouse button*, note and record the value for DX.

2—Repeat Step 1 except draw the line from the top of the image to the bottom and record the value for DY.

studying data spatial resolution

Do F now.

5a. How many pixels wide (DX) is the image? _____

5b. How many pixels high (DY) is the image? _____

These images have

6a. _____ pixels per degree of latitude and

6b. _____ pixels per degree of longitude.

7a. Therefore, the smallest SST feature that can be resolved in these images (the spatial resolution) is

7b. The images in this data set have a spatial resolution of

_____ latitude by _____ longitude.

Some characteristics of Earth observing satellites make it difficult to interpret the data without some considerable manipulation. One such characteristic of thermal-infrared sensors such as AVHRR is the inability to “see” the ocean’s surface in the presence of clouds. For this reason, and to reduce the overall data volume, we will use monthly averaged images in these exercises. It is useful, however to consider a satellite image of the ocean’s surface temperature for a single day.

Open the file `Desktop | HD | SEE Image | Data | Oceans | sstex1 | gd94182.tif` and apply the SST LUT, if necessary. This image depicts the SST distribution for a single day, July 1, 1994. What colors represent land and missing data (clouds) in this image?

8a. Land _____

8b. Clouds _____

9a. Estimate what percentage of Earth is covered by ocean: _____

9b. Estimate the percentage of ocean area covered by clouds: _____

10a. Discuss the benefits and drawbacks of monitoring the ocean temperature using daily images such as this one.

10b. Discuss the benefits and drawbacks of monitoring the ocean temperature using monthly images.

Close all images and select 'Analyze/Reset' before proceeding to the next section.

the relationship between pixel value and sst in degrees celsius

Repeat **Steps B and C** to open and color a data file from either year.

11. Record the month and year of the image you opened.

Month: _____ Year: _____

Move the cursor around in the image you opened. Look at the number associated with Value in the Info Window. These are the pixel values associated with each color. The images are stored as byte data with pixel values between 0 and 255 ($2^8 = 256 = 1$ byte). This is a way to compactly store data in a digital format. As you move your cursor around in the image using the mouse, the Info Window shows you the X and Y coordinates of the current position of the cursor, relative to the lower left corner of the Display Window, and the pixel Value associated with that position in the image. Become familiar with this notation before moving on.

The relationship between pixel values, which range from 0 to 255, and the actual SST values, which range between 0.0°C and 35.0°C , is an important one to understand. Pixel values of 0 and 255 are the only two that do not correspond to an SST value in degrees Celsius. They are always reserved to delineate certain features of an image.

12a. What pixel value is associated with black? _____

12b. What is represented by these pixel values?

12c. What pixel value is associated with white? _____

12d. What is represented by these pixel values?

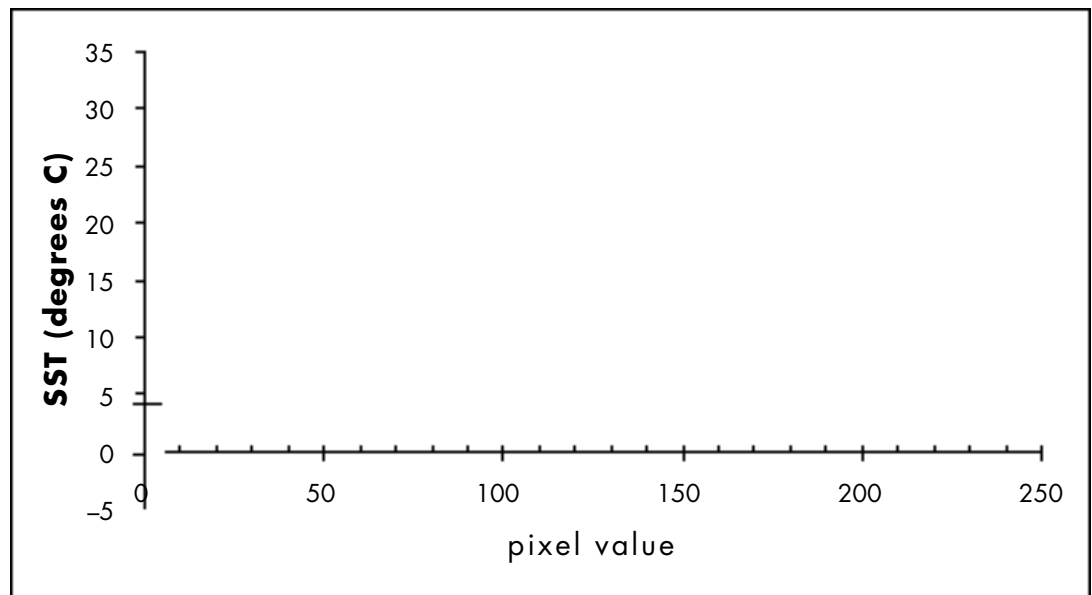
The following table contains the pixel values from one of the global, monthly-average SST images (we'll call this variable A). Move the cursor along the color legend on the Display Window so that the Value in the Info Window corresponds to each of the pixel

values in column A. Read the corresponding SST value from the color legend (get as close as you can within the 5° increments), and write the degree amounts in the B column of the table.

13.

	A Pixel Value	B SST (°C)
1	2	
2	34	
3	74	
4	101	
5	152	
6	185	
7	208	

14. Graph the above pairs of numbers on the axes below.



15. Study the graph of points you just plotted. Describe the relationship between the pixel values and corresponding SST values (in °C). How are they related?

It appears that the points lie along a straight line; i.e., there is a linear relationship between pixel values and SSTs.

16a. Draw a “best fit” line that comes closest to connecting the points on the graph.

16b. Is the slope of this line positive or negative? _____

16c. Is the Y-intercept of the line positive or negative? _____

A line, like the one you drew to connect the points you plotted can be described by the following equation.

$$y = mX + b$$

where

m is the slope of the line

b is the Y-intercept (the value of Y when X=0)

The slope of a line is described by the following equation.

$$m = (Y_2 - Y_1) / (X_2 - X_1)$$

17a. Find the slope (**m**) of the line you graphed by substituting values of X1, X2, and Y1, Y2 from the table on page 11 into the above equation. Do this for more than two X, Y pairs to convince yourself of the result.

m = _____

17b. Now find the Y-intercept (**b**) by reading the value of Y when X = 0 from your graph.

b = _____

17c. Substitute **m** and **b** into the equation of a line as it is written below.

$$SST = m(\text{pixel value}) + b$$

Congratulations! You just derived the relationship between pixel values in an image and SST in °C.

Now compare your Question 14 plot with others in your class.

18. How alike are they and why?

The range of pixel values in these images is from 1 to 254 (remember that 0 and 255 correspond to land and ice, respectively).

19. Using the equation you just derived, what is the corresponding range of SSTs?

Remember, you may always simply read the SST value from the color bar legend provided in the Display Window.

Move your cursor over regions of land and ice in the image and study the values in the Info Window. Move your cursor all around the image now and answer the following questions.

20. What is the approximate range of temperature values displayed in this image and where in the oceans are the coolest and warmest SSTs? Fill in the values.

COOLEST REGION

Pixel Value= _____

SST= _____°C

Color= _____

Location is _____

WARMEST REGION

Pixel Value= _____

SST= _____°C

Color= _____

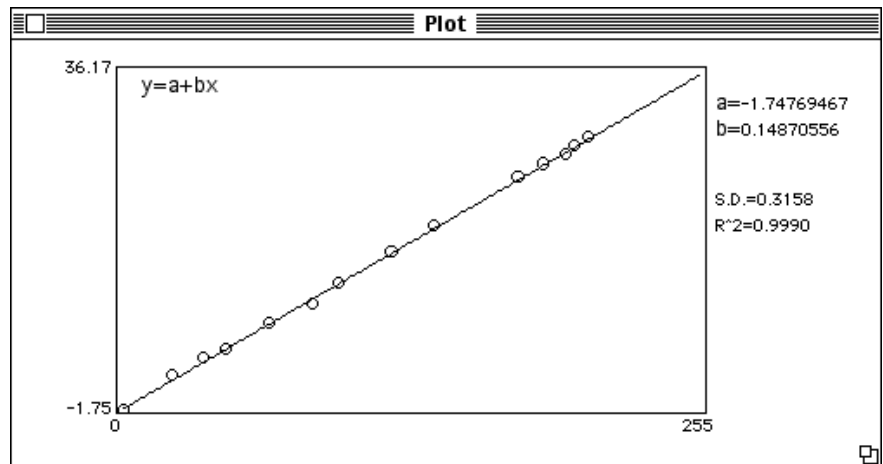
Location is _____

Close all images before proceeding to the next section.

G*make a calibration standards file, continued*

will save these calibration points in a file so that next time you need to calibrate an image you simply open this standards file. Click OK. You'll again see the Calibration dialog box.

12—Click OK and a plot window will appear that shows you the points you selected from the image, the line of best fit through those points, and the coefficients of the line of best fit. You may close this plot without saving it.



Now move your cursor around in the image and watch the Info Window. You will see the actual SST displayed for each pixel, with the corresponding pixel value in parentheses.

HINT: Once an image has been calibrated, an open diamond appears to the right of the file name across the top of the image.

If you will be working with many images during a given session (which is the case for many of these exercises), calibrate the first one you open at the beginning of the session. All subsequent images will then be calibrated and you'll know that they are by the presence of the open diamond (in a stack, the open diamond appears to the left of the file name). Likewise, if you will be working with a series of images in a stack, first create the stack, then calibrate the first image in the stack and the rest will automatically be calibrated.

In summary, to use a previously saved standards file, follow these steps.

- Select 'Analyze/Reset' and Continue
- Select 'Analyze/Calibrate'
- Select the Straight Line button
- Type "deg C" in the box titled Units of Measure
- Select 'File/Open,' find the standards file you saved earlier
- Click OK.

Before proceeding to the next exercise,

- Close all images
- Select 'Analyze/Reset' to clear all measurements.

end of sea surface temperature computer lab exercise 1