exercise 3
observing the seasonal variation of sea surface temperature (sst)

This exercise has five sections. In the first three you'll use some of the tools from *SEE Image* to explore the seasonal variation of SST in a *qualitative,* or descriptive manner, where you'll

- Use a familiar *SEE Image* tool, the Density Slice, to observe the temporal variability from month to month
- * Learn to create a movie of the monthly images, called an Animation
- * Create a Montage of the twelve monthly images to observe SST changes throughout the seasons.

The last two sections of this exercise will hone your *quantitative* skills in analyzing the data, where you'll

- Create and plot a time-series of SST using *SEE Image* to collect the time-series data
- Use Image Math in *SEE Image* to compute the difference between two images.

Do A, B, and C 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. *(If these preferences were already set and you didn't have to change anything, no message box will appear. Skip to step 8.)*

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.*

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

B

make a stack of color images

1—Select 'File/Import'.

2—Go to Desktop | HD | SEE Image | Data | Oceans | sstex3 and double click on the 1995 folder. Click the "Open All" box then click OK.

3—Select 'Stacks/Windows to Stack' to put all 12 months in a stack. Use the > key (also the . key) to move forward through the stack and the < key (also the , key) to move backward through the stack.

4—Select 'Options/Color Tables/SST'. Note that the color LUT will be applied to all images in the stack.

5—Choose 'Options/Preferences' and select "Display Slice Titles Only." This will display the files names across the top of the stack when you move through the stack images with the > and < keys.

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C

calibrate the top image of the stack with a saved calibration file

1 — Select 'Analyze/Reset' and 'Continue.'

2 — Select 'Analyze/Calibrate.'

3 — Select the Straight Line Button. Type 'Deg. C' in the box titled Units of Measure.

4 — Select 'File/Open' and find the calibration standards file you saved and named "SST_Standards" in Exercise 1. Click OK.

NOTE: if you don't have the file because you skipped Exercise 1, Step G, go back and do it now.

D

density slice your stack

1 — Select the Density Slice Tool

from the Tools Window, which will put a solid block of color (default is red) on the LUT window.

2 — Select the Eyedropper

from the Tools Window. Move your cursor to the middle of the solid block of red on the LUT. Notice that the cursor arrow turns into an Eyedropper when it is positioned in this density slice block on the LUT.

3 — Double click with the Eyedropper on the red color block in the LUT window to bring up a color wheel and click once in the middle of the wheel. The window will now display gray as the "New" color. Click OK. The Density Slice color block (and the paint brush) in the LUT window should be gray.

4 — Click once on the Density Slice Tool to reactivate it.

5 — Click, hold, and drag the Density Slice color block to the warmest temperatures on the image's color bar (between 28°C and 32°C).

6 — Using the > key, move slowly through the images in the stack, a month at a time, and watch what happens to the range of SSTs you've highlighted with the Density Slice Tool.

Calibrating the top image in the stack will cause all images in the stack to be calibrated with the same calibration standards. An open diamond is displayed to the left of the file name in the title bar of the stack when the images have been calibrated.

use the density slice tool to observe monthly changes in sst

To begin your observations of how SST changes with time throughout a year, use the Density Slice Tool as you were instructed in Exercise 2, Step E. This tool allows you to identify a range of temperatures with a contrasting color and step through the images in the stack superimposing this temperature range on each image.

Position the stack with the January image on top by using the > or < keys.

Do D now.

1. Describe what happens to the warm SSTs as you advance through the monthly images.

Position the stack with the January image on top once again but this time move the Density Slice Tool until it corresponds to the coldest temperatures on the image's color bar (between about 2°C–7°C) and move slowly through the stack again.

2. Describe what happens to the cool SSTs in each hemisphere.

Study the cool SSTs in the southern oceans.
3a. Is there much north-south variation in SST from month to month in this region?

3b. Comment on the variation you observe in the southern high latitudes as compared with the same SST range in the northern high latitudes.

4. What's the explanation for what you observe?

Double click on the Density Slice Tool to deactivate it. Do not close the stack.

investigating seasonal variations in sst from an animation

A technique commonly used by scientists to visualize data collect-
ed over time is called animation. Each image in a stack is dis-
played automatically, and in sequence, to give the impression of a
movie.

E

animate your stack

1 — Select 'Stacks/Animate' to animate this stack. Use the
number keys from 1 to 9 to control the speed. To stop the
animation, click anywhere on the image.

Do E now.

5. Describe what you see. Does this technique of animating the
monthly SST images bring anything new to light in your observa-
tion of the seasonal variation of SST?

6. Paying close attention to western boundaries, especially in the
North Atlantic and the North Pacific, describe the SST variability
in these regions.

*Return the January image to the top of the stack before proceed-
ing.*

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investigating SST seasonal variation from a montage

F

make a montage of your stack

1 — Select 'Stacks/Make Montage.' Enter "4" for columns, "3" for rows, "1" for increment, and leave the rest at the default. You'll see cameos of all 12 months' images on one screen.

2 — Now experiment. Try entering 3 columns, 2 rows, and 2 for the increment. This will display a montage of every other month, and each cameo will be larger. You can montage the first 6 months by entering the same columns and rows and "1" for the increment, as another example.

Do F and G now.

7a. In what months are SSTs **warmest** in the **Northern Hemisphere**?

7b. Where do they occur and what are the approximate values?

G

study the northern hemisphere in the montage

1 — Select the Rectangle Tool

from the Tools Window and select the entire Southern Hemisphere from the top row of images.

2 — Select 'Edit/Cut' to remove the selection.

3 — Repeat steps 1 and 2 for each row of images in the Montage.

8a. In what months are SSTs **coldest** in the **Northern Hemisphere**?

8b. Where do they occur and what are the approximate values?

H

study the southern hemisphere in a montage

1 — Select 'Stacks/Make Montage.' Enter "4 (or 3)" for columns, "3 (or 2) " for rows, "1 (or 2)" for increment, and leave the rest at the default.

2 — Use the Rectangle Tool again, this time selecting the Northern Hemisphere and using 'Edit/Cut' to remove the selection from each row.

Do H now.

9a. In what months are SSTs **warmest** in the **Southern Hemisphere**?

9b. Where do they occur and what are the approximate values?

10a. In what months are SSTs **coldest** in the **Southern Hemisphere**?

10b. Where do they occur and what are the approximate values?

Comparing the two montages you just made,
11a. do the Northern and Southern Hemispheres have the same approximate range of SSTs?　　Yes ＿＿　　No ＿＿

11b. Is this what you would expect?　　Yes ＿＿　　No ＿＿

11c. Why?

Close the montages but leave the stack open to use in the next section.

creating an sst time-series to observe seasonal variations

Now we'll perform some analysis on the monthly SST data identical to that performed by scientists in their research for studying the temporal variation of a geophysical parameter. You'll use *SEE Image* to compute the average SST in a Northern Hemisphere ocean basin for each month and create a plot of the SST as a function of month. You'll do the same thing for a Southern Hemisphere ocean basin. Comparing the two plots will clearly show how the seasons affect SST.

Do I now.

12a. What is the significance of this image of the standard deviation of SST computed over 12 monthly images?

12b. What is it used to illustrate?

13a. What do areas of red correspond to?

13b. What do areas of green and blue correspond to?

14a. In the Pacific and Atlantic Oceans, what range of latitudes has the highest standard deviations?

14b. What range of latitudes has the lowest standard deviation?

|
use a calculation macro

1 — Select 'Special/CalcSDStack.' You'll be asked to name the resulting standard deviation image. NOTE: the resulting image is automatically calibrated such that the values shown in the Info Window, when you move the cursor around the image, represent the standard deviation in °C of each pixel.

J

plotting deviations

1 — Select the Rectangle Tool from the Tools Window. Using the standard deviation image as a reference, select a region of *high standard deviation* in the North Pacific Ocean and draw a small rectangle over this region on the top (January) image in your stack.

2 — Select 'Analyze/Reset' to clear all measurements.

3 — Select 'Analyze/Options' and choose "mean" and "standard deviation."

4 — Select 'Analyze/Show Results' to see the Results Window on your screen. Position this window so you can see both the Display and the Results windows.

5 — Select 'Analyze/Measure'. You'll see the mean and standard deviation appear in the Results Window for the region you selected on the January image.

6 — Use the > key to move to the next window (February) in the stack and notice that the rectangular selection you did in Step 1 automatically appears on this image. Select 'Analyze/Measure' again. There are now two measurements in the Results Window; January's and February's. Repeat this step a month at a time until you've completed all 12.

7 — Save the Results Window by selecting 'File/Save As" and naming the file with something you'll recognize later.

8 — Use the < key to position the January image back on top of the stack.

9 — Now place the cursor arrow over the middle of your selected region (see the color picture, top right). Click and hold the mouse and drag the rectangle to an area of high standard deviation in the North Pacific Ocean. Repeat Steps 2–7 for the South Pacific.
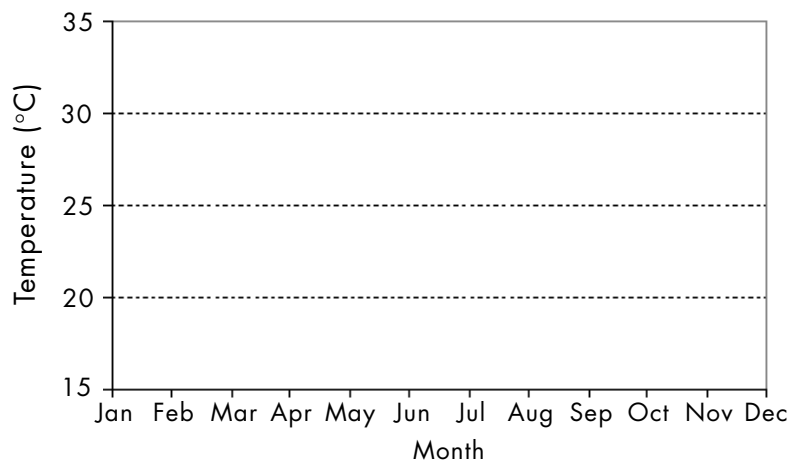
10 — Open the two results files you saved and type in the name of the month in place of the number in the first column for each row of measurements.
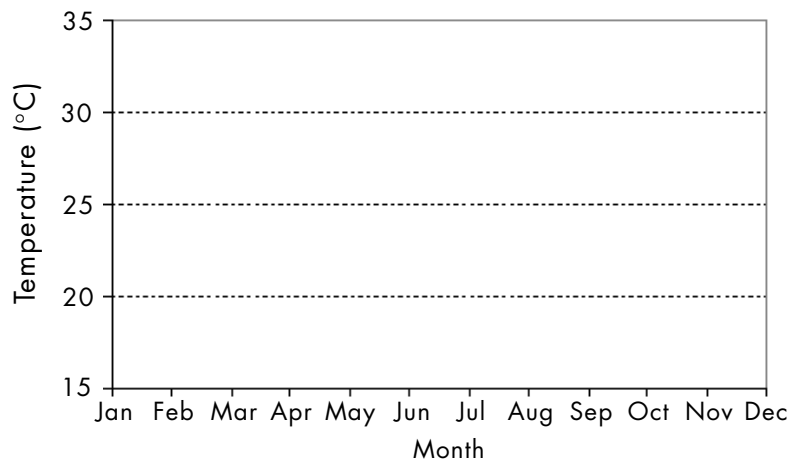
Do J now.

December 1995
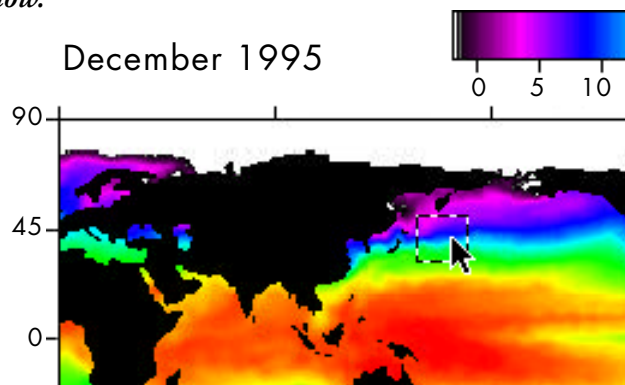
Now create two plots of these data, either by hand or using a plotting package you may have. Plot the months on the x-axis and the mean SST on the y-axis for both
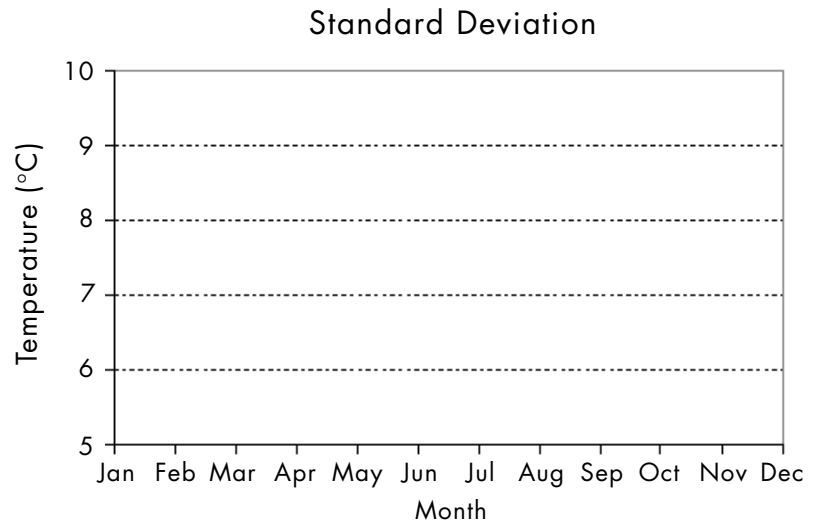
15a. the North Pacific Ocean and

Mean

15b. the South Pacific Ocean.

Mean

15c. Now create a plot with the month plotted on the x-axis and the standards deviation for the North Pacific and the South Pacific on the y-axis.

Standard Deviation

15d. Write a discussion interpreting the plots, comparing the North and South Pacific, and including reasons for the trends and magnitudes of the curves. use additional paper as needed.

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using image math to observe the seasonal variation in sst

Another type of analysis used to see how data change with time is to simply subtract one image from another.

If you still have a stack open, close it now, along with any other open windows.

Do K now.

The resulting image represents the arithmetic difference between the 2 months. Notice that this "difference image" is very uniform in color, mostly shades of green. We can highlight the temperature differences between March and September with a more appropriate range of colors by manipulating the color LUT.

Do L now.

K

make a "difference image"

1—Open one image for March and make sure the SST color table has been selected.

2—Calibrate the image (see Step C).

3—Open the September image for the same year. Make sure the image is calibrated by checking for the open diamond to the right of the file name.

4—Select 'Process/Image Math' and choose the files such that the March image is subtracted from the September image. Select (* 1.) and (+0.). Since the images are calibrated, select "real result."

L

use the lut to enhance the colors

1—Click on the top of the LUT and drag it down to increase the amount of blue and purple in the image.

2—Click on the bottom of the LUT and drag it up to increase the amount of red in the image.

3—Continue to manipulate the LUT in this way until you have a range of colors that best highlights the SST differences between the two months. Use the cursor to move around the resulting image checking the values in the Info Window.

16a. What colors represent positive values?

16b. What colors represent negative values?

17a. What does it mean when the differences are positive?

17b. What does it mean when the differences are negative?

18a. Where in the oceans are the differences between March SST and September SST positive?

18b. Why?

19a. Where in the oceans are the differences between March SST and September SST negative?

19b. Why?

20a. Where are the largest differences?

20b. Where are the smallest differences?