

exercise 8

investigating ozone distributions in 1979 and 1992 using monthly and yearly global average ozone values

NOTE

Throughout these exercises, the navigational paths shown in italics are for use only by those who are using the TOMS Ozone CD set as their data source.

A

importing multiple TOMS monthly average images for 1979

1—Insert the disk *OPT_004A* from the TOMS set.

2—Select 'File/Import TOMS ASCII'

3—Enter "95" for the Minimum value for scaling, "601" for the Maximum Value for scaling, and "12" for the number of images to process. Click OK.

4—Go to Desktop | HD | SEE Image | Data | Ozone | ozex8 | Y79 | GM7901.N7T

Desktop | OPT_004A | Y79 | GM7901.N7T. Click Open. 12 images will open sequentially.

B

stacking and coloring the images with the same LUT

1—Select 'Stacks/Windows to Stack'.

2—Click on the stack of images to activate.

3—Select 'Options/Color Tables/TOMS' and the top image (titled GM7901.N7T GM7901.N7T) will be displayed in color. All other images have also been colored.

Note: Because we are analyzing the TOMS images in various ways in this exercise we will not apply an overlay. If you would like to determine a particular latitude or longitude on an image as you are working, select 'Special/ShowLatLon'. Click inside the image window and as you move the cursor over an image, the latitude and longitude will be displayed in the Info window.

In Exercise 7 we investigated changes in ozone values for 1979 and 1992 using monthly averaged images. In this investigation we will use the same images but will apply some image mathematics to look at regional and temporal variations in ozone distributions.

BEFORE YOU BEGIN THIS EXERCISE

make sure you have read through the Introduction to Module 1: Stratospheric Ozone Computer Lab Exercises document and have completed Sections 1–4 of the tutorial, *Using SEE Image With TOMS Ozone Data*.

Do A and B now.

investigating a yearly standard deviation image from the monthly averaged image

To compare how ozone values for individual pixels around the globe compare to the global yearly average we can compute the standard deviation which measures the variability for each pixel. This will create an image whose pixel values are the standard deviations for each X/Y cell (pixel) in the image.

C

creating a yearly standard deviation image from the monthly averaged image

1—Select the stack with the 12 monthly averages for 1979.

2—Select 'Special/CalcSDStack'. Enter "GlobalSD79" for the image title.

Do C now.

Move the cursor over locations on the GlobalSD79 image. You will see the Value in the Info window change.

1a. What colors represent the least standard deviation values?

1b. What colors represent greatest standard deviation?

2a. What region (north or south polar, north or south midlatitude, tropical) shows the least standard deviation in ozone values over the 12 months? Is this expected? Explain.

2b. What region experienced the greatest month-to-month deviation in ozone values? Is this expected? Explain.

investigating global changes in ozone values using global averages

Another parameter used to investigate temporal changes in ozone values is a monthly or yearly average value. This is a single value that represents the average of all pixels in an image (or all appropriate data points in a global set). If the image (or data set) used is a monthly average the value is called the global monthly average (or mean) ozone. If the value is computed from a year of daily

data it is termed the global yearly average (or mean) ozone. In this exercise we will use monthly average images to generate the global yearly average. Some error will be introduced into our results.

There are two considerations we must address when calculating a global average ozone value using an image generated from a TOMS gridded data set. First, when we import a gridded TOMS data set, the values are displayed in a rectangular grid. The gridded data provide a value for total column ozone for each pixel for a region that is 1° latitude tall by 1.25° longitude wide. This represents a larger surface area at the Equator and a progressively smaller surface area as you move toward the polar regions. Since this is not an equal area image, generating an average from this image using the CalcImageStats macro will introduce error and give increasingly more weight to values as you move away from the Equator. The second concern involves no-data regions. Because of polar night there will be data missing from polar regions during various months of the year. Since we have no information on the ozone values in these regions for certain times of the year, any average we calculate will be biased. Ozone research scientists studying temporal trends in global ozone values generally use the region between 64°N and 64°S to compute the global average. This eliminates the polar regions, which have incomplete data.

To address these concerns we will use a macro called TOMS Adjusted Stats that will calculate a mean by applying a weighting factor to compensate for unequal areas and will ignore data in the polar regions.

exploring stratospheric ozone using TOMS ozone data—computer lab exercises

D

calculating a global average ozone value for each month and for the year

1 — Select the stack of monthly images (GM7901.N7T–GM7901.N7T)

2 — Make sure the image at the top of the stack has the title GM7901.N7T–GM7901.N7T. If not, adjust it with the comma (,) key.

3 — Select ‘Analyze/Reset’. This will clear the Result window where the mean values and standard deviations will be displayed. This window appears when the analysis is complete. If a message appears about lost measurements click Continue.

4 — Select ‘Analyze/Options’ and set the Digits Right of Decimal Point to “0.” Leave the rest at the default settings and click OK.

5 — Select ‘Special/TOMS Adjusted Stats’.

After the analysis finishes (progress can be monitored with a line processing message in the Info window), the image means and standard deviations for each image in the stack are displayed in the Results window. The mean represents a global average for that image. Place the mean and standard deviation values in the table provided.

6 — Select ‘Special/CalcAverageStack’ and name the resulting image “GlobalAve79.”

7 — Select ‘File/Save As’ and name the image “GlobalAve79” and put it in Desktop | HD | SEE Image | Images | Ozone.

8 — Select the GlobalAve79 image. Select ‘Special/TOMS Adjusted Stats’ to calculate the global yearly average for 1979. This will appear as measurement 13. Record the value in the table.

Do D now.

Image		Mean		Standard Deviation (SD)	
#	Month	1979	1992	1979	1992
1	January				
2	February				
3	March				
4	April				
5	May				
6	June				
7	July				
8	August				
9	September				
10	October				
11	November				
12	December				
13	Yearly Average Ozone				

Information for completing the 1992 columns will be provided later in the exercise.

investigating the global average ozone values for each month and for the year during 1979

Compare the mean and standard deviation results of the yearly average with those from the monthly images. If you have access to a graphing calculator or computer graphing utility you may wish to plot the global mean values or the standard deviations against the month (1–12) to look for patterns in the data.

3a. Is there pattern in the global mean values for 1979? Explain.

3b. Which month(s) varies most based on the standard deviation values?

Why might you expect this?

3c. Which month(s) varies least based on the standard deviations.

Is this expected based on previous observations in these exercises? Explain.

Close all stacks and images currently open.

investigating changes in ozone values from 1979 to 1992

Now that you have had a chance to see how we can use averaged data to look at changes during a year you can use that expertise to generate data to compare ozone values from 1979 to values from 1992.

E

generating monthly and yearly averages for 1992

1 — Repeat Procedures A–D for the 1992 data, replacing *OPT004A* with *OPT004B* and 79 with 92 where appropriate. Go to Desktop | HD | SEE Image | Data | Ozone | ozex8 | Y92 | GM9201.N7T
Desktop | HD | OPT_004B | Y92 | GM9201.N7T to import the 12 monthly average images for 1992. Record mean and standard deviation values in the table above.

Do E now.

investigating a global total ozone value for each month and for the year during 1992

Compare the mean and standard deviation results of the 1992 yearly average with those from the 1992 monthly images.

4a. Which month(s) varies most from the yearly mean?

Is this expected based on previous observations in these exercises? Explain.

4b. Which month(s) varies least from the yearly mean?

Is this expected based on previous observations in these exercises? Explain.

investigating global average ozone values in 1979 and 1992

Now that you have looked at seasonal variation in ozone values for 1979 and 1992, let's investigate changes that have occurred from 1979 to 1992. Use the table of means and standard deviations you generated to answer the questions below.

5a. What general statement can you make about the mean monthly ozone values in 1992 compared to 1979?

5b. What general statement can you make about the average yearly ozone values in 1992 compared to 1979?

5c. Does the same trend in mean values over a period of a year hold for the 1992 as for the 1979 data? Explain.

Are there any months that appear to deviate more from the mean than others? Explain.

5d. How do the standard deviations for the global averages for 1979 and 1992 compare? Explain what this means.

Close the stack GM9201.N7T–GM9201.N7T. Keep GlobalAve92 open. Close the Results window.

producing a ratio of two images to visualize regional change in global average ozone values between 1979 and 1992

If we are interested in looking at the regions that have changed the most in yearly average ozone we can compare the 1979 and 1992 global average images to one another using an image math operation. The *SEE Image* processing technique used to visualize the difference between two images involves determining the ratio of the images. Since each pixel represents a value, we can compute a ratio of each corresponding pixel on two images. The result is an image where numbers greater than one indicate areas where the numerator image had a higher value and numbers less than one indicate areas where the denominator image had a higher value. The further the resulting value is from one, the greater the difference between the two images.

We will ratio the yearly average 1979 and 1992 images.

exploring stratospheric ozone using TOMS ozone data—computer lab exercises

F**generating a ratio image**

1—Select 'Open'. Go to Desktop | HD | SEE Image | Images | Ozone | GlobalAve79. Click OK.

2—Select 'Analyze/Options'. Be sure that Digits Right of Decimal Point is 2. Click OK.

3—Select 'Process/Image Math' to activate the ImageCalculator.

4—Select the 1979 image (GlobalAve79) from the uppermost drop-down menu. Select the 1992 image (GlobalAve92) from the second drop-down menu (underneath the first one).

5—Select the symbol for division from the operation drop-down menu. Enter "1" in the box next to the times sign (X) since we do not want to multiply the result by a constant. Enter "0" in the box next to the plus sign (+) since we don't want to add a constant the resulting image. Type "1979/1992" in the box next to the equal sign (=). This will be the name of the output image. Select the "Real Result" check box since some of the resulting image pixel values will be outside of the 1–254 range. Click OK to perform the mathematics.

Do F now.

Move the cursor over the various pixels in the 1979/1992 image and look at the Value in the Info window.

6a. What region(s) (north or south polar, north or south midlatitude, tropical) showed higher yearly average ozone values in 1979 than 1992? Explain.

6b. Did any region show higher yearly average ozone values in 1992 than 1979? Explain.

6c. Which region(s) showed the greatest change in yearly average ozone values? Is this expected? Explain.

6d. Which region(s) showed the least change in yearly average ozone values? Is this expected? Explain.

Close all images when finished.