

## exercise 2

# comparing daily ozone values over the globe to the daily average and investigating ozone distribution patterns

There is variation in ozone values across the globe at any given time. In this exercise we will work with a single date TOMS image to investigate this variation. We will start by calculating the global average ozone for September 1, 1991. This global average ozone value will be used as a reference to compare with several ozone values in the image. We will then use a gridded monthly image to investigate some general characteristics of ozone distribution.

## 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 the September 1, 1991, image*

1—Insert the disk *OPT\_004B* from the TOMS set.

2—Select 'File/IMPORT TOMS ASCII' and input "95" for the Minimum value for scaling and "601" for the Maximum value for scaling. Select 1 as the number of images to process. Click OK.

3—Go to Desktop | HD | SEE Image | Data | Ozone | ozex2 | GA910901.N7T

*Desktop | OPT\_004B | Y91 | M9109 | GA910901.N7T.*

## B

### *coloring the image with a consistent color table*

1—Select 'Option/ColorTables/TOMS'

## 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.*

## calculating global average ozone for September 1, 1991

A daily global average ozone value for an image is a single value that is the average of all the ozone values in that image. We can perform this calculation with a SEE Image macro called CalcImageStats. When using this macro to determine an average, all pixel values are treated as representing equal areas. Because this is not an equal area image (the surface area of a pixel on the equator (~15400 km<sup>2</sup>) is much greater than the surface area of a pixel near the poles (~100 km<sup>2</sup>)), some error is introduced into the calculation of the global average ozone value. We will not try to correct for this during this exercise since we are interested in relative values and patterns of ozone distribution. All pixels with no-data values are ignored when using this macro so they do not add error.

## exploring stratospheric ozone using TOMS ozone data—computer lab exercises

Would you expect significant changes in daily global ozone values within a year or between years? Explain.

Normally, the daily global average ozone value would not be expected to change significantly on any given day throughout the year or between different years.

*Do C now.*

Global Average Ozone Value \_\_\_\_\_

## C

*calculating an average using CalcImageStats*

1—Select the GA910901.N7T image (September 1, 1991). Select 'Special/CalcImageStats'.

*The progress of the calculation can be monitored with a line processing message in the Info window. After it is finished, the image mean and standard deviation are displayed in the Results window.*

2—Record the mean value below.

**comparing individual pixels to the daily global ozone average**

The value generated above is the daily global average ozone value for this day. The value in parentheses is the grayscale value which can range from 0 to 255. It can be ignored for this analysis. We can compare this value with individual ozone values at various locations to see if they are greater than or less than the global average. To add points of reference we will apply an overlay to the image before continuing.

*Do D now.*

On this overlay latitude lines appear at 30° intervals; lines of longitude appear at 60° intervals. For purposes of this exercise we will define the region from 60–90° latitude as polar, 30–60° as midlatitude, and 0–30° as tropical.

1. Select the GA910901.N7T (September 1, 1991) image. Move the cursor onto the colored portion of the image and look at the Info window for the number after Value. This number is the ozone value in Dobson Units (DU) for the pixel under the cursor.

What do areas of black represent?

## D

*adding an overlay of continents on an image*

1—Select 'File/Open'.

2—Go to Desktop | HD | SEE Image | Overlay | LATLONG.TIF and click on "Open." An image with the outline of the continents and latitude/longitude lines will be displayed.

3—Select the LATLONG.TIF image then select 'Edit/Select All' followed by 'Edit/Copy Selection'.

4—Select the GA910901.N7T image and select 'Edit/Paste'. The overlay image will completely cover the base image at this point.

5—Next, select 'Windows/Show Paste Control'.

6—In the Paste Control window, click and hold the Transfer Mode pop-up menu ('Copy' is the default setting) and select 'Replace'.

7—Select 'Windows/Hide Paste Control' to close the Paste Control window.

8—Select the LATLONG.TIF window and close it.

## exploring stratospheric ozone using TOMS ozone data—computer lab exercises

2. Compare the values of individual pixels at different locations with the global average. Record the general latitudinal region the pixel falls in (north or south polar, north or south midlatitude, north or south tropical), the associated ozone value in Dobson Units (DU), and whether the value for the pixel is above, below or roughly comparable ( $\pm 10$  DU) to the daily global average value for the same day.

Pixel Location (X,Y)	Latitudinal Region	Ozone Value (DU)	Comparison to Global Average (higher, lower, same)
10, 15			
120, 20			
50, 75			
62, 72			
15, 95			
230, 100			
20, 130			
100, 145			
185, 145			

3a. What color or color ranges are associated with the following.  
 daily global average ( $\pm 10$ ) \_\_\_\_\_  
 values above the global average \_\_\_\_\_  
 values below the global average \_\_\_\_\_

3b. Is there a pattern of distribution for the ozone values? Explain.

3c. Where are the areas containing the highest and lowest values located? Is this expected? Explain.

*Close the GA910901.N7T image when you are finished.*

## exploring stratospheric ozone using TOMS ozone data—computer lab exercises

**E*****importing and coloring the gridded monthly September 1991 image***

- 1—Insert the disk *OPT\_004B* from the TOMS set.
- 2—Select 'File/IMPORT TOMS ASCII' and enter "95" for the Minimum value for scaling and "601" for the Maximum value for scaling. Select 1 as the number of images to process. Click OK.
- 3—Go to Desktop | HD | SEE Image | Data | Ozone | ozex2 | GM9109.N7T  
Desktop | *OPT\_004B* | Y91 | M9109 | GM9109.N7T and click on Open.
- 4—Select 'Option/ColorTables/TOMS'

**F*****making a copy of the September 1991 image***

- 1—Select the September 1991 image (GM9109.N7T) and then select 'File/Duplicate'. This will duplicate the image and will append "Copy" to the title in the new image window.

**G*****adding an overlay of continents on an image***

- 1—Select 'File/Open'.
- 2—Go to Desktop | HD | SEE Image | Overlay | LATLONG.TIF and click on Open. An image with the outline of the continents and latitude/longitude lines will be displayed.
- 3—Select the LATLONG.TIF image then select 'Edit/Select All' followed by 'Edit/Copy Selection'.
- 4—Select the GM9109.N7T image and select 'Edit/Paste'. The overlay image will completely cover the base image at this point.
- 5—Next, select 'Windows/Show Paste Control'.
- 6—In the 'Paste Control' window, click and hold the Transfer Mode pop-up menu ('Copy' is the default setting) and select 'Replace'.
- 7—Select 'Windows/Hide Paste Control' to close the Paste Control window.
- 8—Select the LATLONG.TIF window and close it.

**observing patterns in ozone distribution from the TOMS data**

You probably noticed some patterns in the ozone distribution from the September 1, 1991 image. To investigate this further we will use a gridded monthly image for September 1991 that is generated from the September 1991 daily images. We will interpret the image with an overlay.

***Do E now.***

Because we will need to use the September 1991 image without an overlay later in this exercise, we will make a copy of it before applying the overlay.

***Do F and G now.***

## exploring stratospheric ozone using TOMS ozone data—computer lab exercises

Observe the September 1991 image with overlay (GM9109.N7T).

**4a.** Do you see a pattern of distribution of ozone values in a north-south or east-west direction?

**4b.** What is the basis for the pattern?

To enhance any patterns we can highlight a range of ozone values using density slicing tool. Density slicing allows the user to take a range of values (block of values) and assign a color to them. The default color is red. The LUT Tool can be used to manipulate the density slice when density slicing is enabled.

First we will define a range of 50 values by moving the upper and lower boundaries of the density slice. The boundaries can be monitored in the Info window. We will use the default color red for the color block. Then we will move the density slice block up and down the LUT window, which will change the upper and lower boundaries of the values that we are interested in highlighting in red.

## H

### *making a density slice with the LUT tool*

1—From the Tools window double click on the LUT tool (horizontal line with an up and down arrow) to enable density slicing. This will put a solid block of color (default color is red) on the 'LUT' window.

2—Place the cursor at the top of the red density slice block in the LUT window; click and drag the cursor (and density block) until the upper limit is equal to 461.

3—Place the cursor at the bottom edge of the red density slice color block in the LUT window; click and drag the cursor (and color block) until the lower limit is 411.

4—In the LUT window, place the cursor on the center of the red color block and click and drag the red density slice block.

### *Do H now.*

Move the density slice color block to the top of the LUT window and then slowly drag it toward the bottom. As you drag the density slice region down the color bar, you will highlight regions with similar ozone values. While you hold down the mouse and move the density slice color block the range of values (upper and lower limits) highlighted will be displayed in the Info window. Do this several times.

**5a.** Record the range of ozone values in Dobson Units for the regions with the following characteristics.

highest values (first appearance of red)	_____
lowest values (last appearance of red)	_____
most area highlighted (greatest red)	_____

**5b.** Does the range of values for the areas with the most highlighting correspond to the global average ozone value? Explain.

**5c.** How do the values in the tropical regions compare to northern midlatitude values? to southern midlatitudes? to the polar regions?

### observing ozone values over areas of high elevation

Would you expect the ozone values to be higher over mountains or valleys? Explain.

To investigate possible differences, we can use the density slice tool.

Select the GM9109.N7T image. Select the LUT Tool. Change the width of the density slice color block as you did in procedures H2–3 so that the difference between the upper and lower limit is 20. Move the density slice color block to the top of the LUT window and then slowly drag it toward the bottom.

*To see features better, select the Magnifying Glass Tool. Click once inside the GM9109.N7T image. You will now see an image twice as large as the original. You can return the image to its normal size by double clicking the Magnifying Glass Tool. You must select the LUT tool again to move the color block when you change the image magnification.*

When the lower value reaches about 251 you will notice an oblong shape north of India.

**6a.** Are the ozone values for this area higher or lower than the surrounding areas?

**6b.** What Earth surface feature(s) might this correspond to?

Drag the color block until the lower limit is about 237 and you will notice a banana shaped object at the northwest coast of South America.

**7a.** Are the ozone values for this object higher or lower than the surrounding areas?

**7b.** What does this feature represent?

**8.** What general statement can you make regarding the ozone values over high topographic regions compared to lower elevations? Why might this be true?

### observing a phenomenon related to continental margins

The TOMS Color Table displays a range of ozone values (25 DU) with a single color. We can display the TOMS data with a color table that utilizes more hues such as “Spectrum”. In this table each color represents a narrower range (2 DU) of ozone values.

#### *Do I now.*

Select the GM9109.N7T image and return it to normal size if necessary with the Magnifying Glass Tool. Place the image next to the “GM9109.N7T Copy” image for land mass reference.

**9.** Examine the “GM9109.N7T Copy” image. Can you see any patterns in ozone distribution that follow land masses? Why might they exist?

#### **|** *coloring the image with a different color table*

1—Select GM9109.N7T Copy (September 1991 without overlay).

2—Select ‘Option/ColorTables/Spectrum’.

International ozone researchers have noticed that when they apply a rich color palette (more than 500 hues) to monthly mean (average) global data they can see the contours of continents appear as “ghost” images. You can see some of this effect using the Spectrum LUT. In fact, researchers call this the GHOST (Global Hidden Ozone Structures from TOMS) effect. They are still trying to determine the causes for this effect.

*Close all images when you are finished.*