exercise 2
seasonal greening of the hemispheres

Vegetation changes throughout the seasons. These changes are offset between the northern and southern hemispheres so when vegetation is greening up in the northern hemisphere it is undergoing senescence in the southern hemisphere.

In this exercise we will compare how NDVI values change throughout the year. We will start by loading up all the 10-day composite NDVI images for 1993 and then color them using the standard NDVI color table. We will then create a mosaic to view all of the images at one time. The next step will be to create a stack and then project the stack to minimize distortions. To view the dynamics of the seasonal changes we will animate the stack. We will use a temporal profile to illustrate how vegetation cover in one place changes over time. We will also see how we can change perspectives on an image through projections.

BEFORE YOU BEGIN THIS EXERCISE
make sure you have completed the following steps—instructions for them are in the *Tutorial.*
- Start *SEE Image*
- Configure *SEE Image*
- Load the SEE_macros

Earth's seasons exist primarily because of the changing angle of incidence of the Sun's rays and the length of time the Sun shines on a particular part of Earth. We can visualize these changes by monitoring vegetation throughout the year.

The normalized difference vegetation index (NDVI) provides us with an indication of how much green vegetation exists at a particular place on the ground. Using these values we can generate an image that can be very useful to study how vegetation changes over time. The vegetation changes that we will study in this exercise are those that are caused by a changing of the seasons.

The formula for NDVI is
$$NDVI = (NIR - RED) / (NIR + RED)$$
where NIR stands for a value from a near-infrared image channel and RED is a red image channel value. This formula is based on

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A

preparing data for observation — importing and stacking images

1 — Select 'File/Import DAAC AVHRR'.

2 — Select the Import DAAC AVHRR NDVI Image radio button. Select all three check boxes: Calibrate images when imported, Use default min and max values for scaling, and Import all images in the folder. Click OK.

3 — Go to Desktop | HD | SEE Image | Data | Veg | vgex2 | NDVI1993. Make sure the NDVI1993 folder is open and an image is selected (it doesn't matter which image is selected) then click on Open. All 36 images will open automatically, overlaying each other.

4 — Select 'Stacks/Windows to Stack'.

B

coloring the images with the same lut

1 — Click on the stack of images to activate it.

2 — Select 'Options/Color Tables/DAAC NDVI'. The stack will be displayed in color.

C

making a montage of the 36 images

1 — Select 'Stacks/Make Montage'.

2 — Enter "6" for columns, "6" for rows, "1" for increment. Leave the rest at the default settings.

the fact that healthy green vegetation reflects a greater proportion of near-infrared light than red light. The NDVI values can range from –1 to +1 with most values ranging from 0 to 0.6. With this information we can see that healthy green vegetation would give us a high NDVI value because more near-infrared light would be reflected than red light. For bare soil on the other hand, both near-infrared and red light are strongly reflected so the NDVI would be near zero. Water and ice reflect a little more red than near-infrared light so those values tend to be slightly negative. The creation of an NDVI image is illustrated in Exercise 1.

Do A, B, and C now.

These composites are processed so that there are three composites per month. For each month, the first 10 days are composited to make the first 10-day composite image and the second set of 10 days make up the second image. The days remaining in the month (11 in the case of January) are composited for the third image of the month. With this information we know that the first three images (1–3) are from January, the second set of three images (4–6) are from February, and so on.

investigating seasonal greening from a montage

You will notice that the colors range from violet to green on the image and LUT. To see the NDVI values associated with specific colors, move the cursor over the color of interest in the LUT window and read the associated NDVI Value in the Info window.

1a. Moving the cursor up and down the LUT, determine the minimum and maximum NDVI values for this image.

Maximum NDVI value _____

Minimum NDVI value _____

1b. How do these values correspond to what you know is the possible NDVI range?

1c. Do you see a distinctive pattern of change as you scan through the images in the montage? Explain.

It may be easier to explore seasonal changes by moving through a stack of images rather than using a montage. We can use our eyes to scan a series of sequential images looking for changes or we can use a technique based on the flip-books or film loops you may have played with or seen as a child. We can animate a stack so that each image is flashed in sequence giving the impression of motion. SEE Image will allow us to animate a stack of images or move through the same stack sequentially.

Do D now.

D

animating and moving sequentially through an image stack

1—Close the Montage image window. You do not need to save it unless told to by your instructor.

2—Click on the stack of images to activate it.

3—Select 'Options/Preferences' and then click on the Display Stack Title and Slice Titles radio button if it has not already been selected. Click OK.

4—Select 'Stacks/Animate'. This cycles through the stack quickly and continuously. To slow down the animation, use the number keys 1–9 to change the speed of the animation. Lower numbers will animate the images at a slower speed, while 9 animates the images the fastest. To stop the animation, click anywhere inside the animated stack window. Note that the title of the stack does not change during the animation to indicate which slice (stack image) is being shown during the animation.

5—To view the stack image by image and retain the slice names with each image, press the period (.) key to look at the next image and the comma (,) key to view the previous image. Notice that this allows you to control how quickly you move through a stack, and you are able to see the stack and slice titles. With this method, though, you cannot cycle directly from the end of the stack to the first slice in the stack. It's necessary to move backward through the stack to get back to the first slice.

investigating seasonal greening from an animation

Animate the stack of 36 images from 1993. As you view consecutive images starting in January the changes in vegetation can be seen.

2. One odd phenomenon is that during the beginning and end of the year the extreme portions of the northern and southern hemisphere disappear. What is a possible explanation for this?

The extreme polar regions disappear because the long polar night at these latitudes prevents the satellite from collecting data.

Flip through each of the images in the stack using the animation or moving through the images one by one concentrating on the northern hemisphere.

3a. What happens to the color as you proceed through the images (or seasons)?

3b. What month(s) represents maximum greening for the northern hemisphere? Which month(s) shows minimum greening?

Now concentrate on the southern hemisphere.

4a. Watching the animation—do you see a similar pattern of change? Explain.

4b. Do the periods of maximum and minimum greening occur at the same time as in the northern hemisphere? Explain.

Let's look at some specific regions to see how the NDVI values change through the seasons. To do this we will use the option of moving through the images sequentially as described in D5. If you are interested in a particular geographic location to study you may wish to review the section at the end of this exercise, "Finding a Geographic Location on an Image From Latitude and Longitude Values."

5a. Make sure that you have returned to the first image in the stack. Select a northern hemisphere location that is seen in all images and seems to change over time, and place the cursor on that point. The equator is located at Y=90 for these images. Record the approximate geographic location of the point below (i.e., U.S. state or region, European country). From the Info window record the X-Y coordinates for the position and the NDVI value below. Keep the cursor in the same position and use the period (.) key to move to the fourth image (first composite image for February) and record the NDVI value in the table on page 5. Repeat this procedure for the same point on the first composite image of each month.

Approximate northern hemisphere geographic location:

_____

Northern hemisphere location coordinates: X= _____ Y= _____

5b. Select a southern hemisphere location that is in all images and seems to change over time and place the cursor on point. Record the approximate geographic location of the point below (i.e., that African or South American country or region). From the Info Window record the X-Y coordinates for the position and the NDVI value below. Keep the cursor in the same position and move to the fourth image (first composite image for February) and record the NDVI value in the table below. Repeat this procedure for the same point on the first composite image of each month.

Approximate southern hemisphere geographic location:

_____

Southern hemisphere location coordinates: X= _____ Y= _____

IMAGE	NDVI VALUE	
	Northern	**Southern**
ND930101		
ND930201		
ND930301		
ND930401		
ND930501		
ND930601		
ND930701		
ND930801		
ND930901		
ND931001		
ND931101		
ND931201		

5c. What is the pattern of change in values from January to December for each hemisphere?

5d. Is the numerical change pattern the same or different for the points you selected in the two hemispheres? Explain.

Looking at the images, you see that the United States begins greening up in April and by the summer months vegetation is at peak greenness. When the northern hemisphere is experiencing peak greenness the southern hemisphere is less green than it was in January.

comparing temporal profiles in the northern and southern hemisphere

Earlier in this exercise you manually collected temporal (time) data for the northern and southern hemispheres to look at patterns in NDVI values as a measure of seasonal greening. We can generate a plot of the temporal data for a location manually or use the capabilities of the image software.

Since we are dealing with a stack of images that change with time we can think of the stack as having a Z-axis, or a time axis. If we sample the same geographic point on each image in the stack we can obtain a temporal, or Z-axis, profile for that location. A macro in the software will allow us to do this and plot the results quickly.

Do E now.

6a. When do the maximum and minimum NDVI values occur for each hemisphere? Record the data in the table on the next page. Express the Month and Day as the date from the image name on the stack title. To assist you, be aware that the values on the x-axis of the profile represent the slices in the stack. For example, the number 1 represents the data for 930101 and 23 is 930811.

E

generating a temporal profile

1 — Select the line selection tool (dashed diagonal line) in the Tools window.

2 — Click the mouse somewhere in the northeast United States. Point X=86, Y=54 is a good one to select.

3 — Select 'Special/Plot Temporal Profile' and enter "0.8" for the maximum value and "–0.3" for the minimum value. Click OK. You will generate a plot of NDVI values as a function of time.

4 — Repeat the last two steps with a point in southern Africa that has high NDVI values in January. Point X=208, Y=105 is good.

	Northern Hemisphere	Southern Hemisphere
Maximum NDVI Value		
Month/Day of Max. Value		
Minimum NDVI Value		
Month/Day of Min. Value		

6b. What do the temporal graphs tell about the seasonal greening patterns in the two hemispheres?

changing perspective — projecting a stack of images

To aid in analyzing a stack of images you may wish to center a particular geographic location or change your view from space. There are several special projection functions in SEE Image you can use to do that.

Map projections are used to represent a spherical object on a flat surface such as paper or a computer screen. For this exercise that spherical object is Earth. Unprojected images are very distorted, which is obvious when you look at the country outline. We can greatly reduce distortion by using different map projections.

There are three map projections that have been incorporated into SEE Image. The first is called the Orthographic projection, which shows Earth as if viewed from deep space. It is often used to view the polar regions that are often distorted when using other projections. In an Orthographic polar projection, the area of greatest distortion occurs in the region around the equator. In SEE Image you can generate a south polar or north polar projection.

The second projection is called Hammer and is used to display global data. Shapes of features are distorted in the Hammer projection, especially near the top and bottom edges, but the area of those features is not distorted. In other words, each pixel in the image represents the same area. For that reason it is often an excellent choice for global analysis. The Hammer projection function allows you to define the center longitude for the projection.

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This allows you to control what portion of the globe will be in the center of the image window.

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

The SEE Image projection functions run very slowly on older 68k Macintoshes. When running the 68k version of SEE Image, a line counter is displayed to show the progress of the projection. If projecting a stack of images, the first slice will take several minutes to be projected but following slices will process in a few seconds.

You can animate or move sequentially through a projected stack of images in the same manner as with unprojected stacks using Steps D4 and D5

Do F now.

Move sequentially through this north polar projection stack. Notice the areas of missing data on a number of the images at the top (ND930101) and bottom (ND931221) of the stack caused by the polar night as described above.

You may generate the south polar projection by repeating the above steps selecting option 2 for a southern projection and entering "South Polar" for the name of the projected image. It is important that the original unprojected stack is selected before launching any projection.

Do G now.

F

generating a polar projection

1 — Be sure the stack of images is active.

2 — Select 'Special/ProjectPole'.

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

4 — Enter "North Polar" for the name of the projected image. Click OK. A new, square, window will be created with the north polar projection of the continents image. Notice how only the northern hemisphere is shown.

G

generating a hammer projection

1 — Click inside the unprojected stack window to make that window active.

2 — Select 'Special/ProjectHammer'.

3 — Enter "Hammer, 100 Degrees West" for the name of the projected image.

4 — Enter "–100" for a reference longitude. This longitude corresponds to the center of the United States, so the resulting image will be centered on the U.S. You will see that the Hammer projection transforms the globe into a football shape.

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finding a geographic location on an image from latitude and longitude values

If you want to locate the X-Y coordinates for a geographic site on one of the NDVI images in this exercise you can do so with a special macro called 'CalcLatLong'. 'CalcLatLon' calculates the image coordinates (X,Y) for a given latitude and longitude coordinate pair. Note that the coordinates calculated by this macro apply only to images that have not been projected.

The macro 'ShowLatLon' can be used with projected or unprojected images to interactively show the latitude and longitude values for a given pixel.

The NDVI images used in this exercise are processed so the northwest (upper left) corner of the image has the coordinates; latitude 90°N and longitude 180°W. Moving in an easterly direction (to the right) each pixel represents a distance of 1.0°. Moving in a southerly (downward) direction, each pixel represents a distance of 1.0°. When locating a feature with known geographic coordinates we must first convert the geographic coordinates, defined by latitude and longitude, to image or pixel coordinates (X and Y). Lines of latitude run east-west around the globe. The best known line of latitude is the Equator, which has a value of 0° latitude. Lines of longitude run north-south and always intersect at the north and south poles. A popular line of longitude is longitude 0° that passes through Greenwich, England. It is standard notation to make lines of latitude south of the Equator negative and lines of longitude west of Greenwich negative.

Do H now.

H

locating a geographic point on an image using 'CalcLatLong' or 'ShowLatLong'

1 — Click inside the unprojected stack window of NDVI images to make it active.

2 — Select 'Special/CalcLatLon'.

3 — Enter "38.9" for latitude and "−77.0" for longitude. These are the decimal degree latitude and longitude coordinates for Washington, DC. In the Info window you should see the results of the calculation "X = 103 for longitude −77.0" and "Y = 51 for latitude 38.9." X=103, Y=51 is the pixel where Washington D.C. is located.

4 — Select 'Special/ShowLatLon'.

5 — Move the cursor around the image while watching the Info window. This provides an interactive display of both latitude and longitude values as well as the image coordinates of the 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).

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