**Studying Earth's Environment** 

From Space

http://see.gsfc.nasa.gov/edu/SEES

## Module 4: Computer Lab Exercises

## EXPLORING POLAR SEA ICE PROCESSES USING NASA SATELLITE DATA

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#### NASA Goddard Space Flight Center, Earth Sciences Directorate

If you have comments, problems or suggestions, please email helpdesk@see.gsfc.nasa.gov

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  - > Use a montage to investigate seasonal variations in SIC
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- Quantitative tools for exploring the interannual variability of Antarctic sea ice distribution
  - > Maximum sea ice extent
  - > Minimum sea ice extent

#### **Exploring Polar Sea Ice Processes Using Satellite Data**

#### Overview

The set of exercises that follow were designed to explore characteristics of polar ice processes using satellite data. These exercises introduce students to basic image processing skills for displaying and analyzing images. Each exercise has scientific discussions explaining what the student is observing. Students will use NASA Image2000, a version of NIH Image, to display and analyze the data sets.

The exercises are inquiry based and designed for advanced high school or introductory level undergraduate Earth science classes and associated Macintosh computer labs. They were designed to be used in concert with an electronic lecture that contains scientific background information on polar sea ice and its satellite observations and includes graphics that can be made into viewgraphs or slides to facilitate development and delivery of lectures. This "eLecture" is the Class Resources component of this SEES module.

The password for the secured Instructor's Guide is available from the DAAC USO—you will need to provide proof that you are an instructor.

#### Why Study Sea Ice

Sea ice is theoretically one of the most sensitive natural indicators of enhanced greenhouse warming. Any increase in the temperature of the atmosphere in the polar regions will reduce the amount of sea ice, which, in turn, will expose more of the relatively warm ocean that was previously covered by the ice pack. This warm water will further heat the atmosphere, and the cycle will continue [1].

Only recently has satellite technology enabled scientists to observe the entire Arctic and Antarctic pack ice year round and in all weather conditions. Unfortunately, this means the record of observations is short (about 20 years); hence, it it is difficult to distinguish the natural variations of the ice from any enhanced greenhouse melting. In fact, it has

Washington, W. M., and G. A. Meehl. 1989. Climate sensitivity due to increased CO<sub>2</sub>: experiments with a coupled atmosphere and ocean general circulation model. Climate Dynamics, V4, 1–38.

<sup>[2]</sup> Barry, R. G., J. A. Maslanik, K, Steffen, R. L. Weaver, V. Triosi, D. J. Cavalieri, and S. Martin. 1993. Advances in sea-ice research based on remotely sensed passive microwave data. Oceanography, V6, 4–13.

been suggested that it may take another decade before results are clear [2]. However, the longest studies to date have shown small, though statistically insignificant, decreases in Antarctic sea ice area [3] and sea ice extent [4]. We must be careful not to read too much into these shortterm results, though it would be equally unwise to dismiss them before an accurate long-term record is established. A worrying indicator, however, is the significant decrease in the Arctic sea ice observed over similar time periods [3], [5].

In these exercises you'll work with a research-quality, 20-year time series of monthly averaged images of sea ice concentration (SIC) from satellites. This is the same data set that was used by many scientists in the research described in the cited references. You'll use these monthly SIC data to investigate

- Geographical distribution of sea ice around the Arctic and Antarctic continents and associated features
- Seasons, or the seasonal cycle (also called the annual variation) as expressed in the sea ice
- Year-to-year variability, also known as the interannual variation, of SIC

#### North And South Polar Monthly Data Set For 1978– 1996

The data set you'll use for these exercises is composed of gridded, monthly averaged sea ice concentration measurements derived from the Nimbus–7 Scanning Multichannel Microwave Radiometer (SMMR) and the Defense Meteorological Satellite Program (DMSP) Special Sensor Microwave/Imager (SSMI). These data are produced by the Laboratory for Hydrospheric Processes at the NASA Goddard Space Flight Center and are archived and distributed for NASA by the National Snow and Ice Data Center (NSIDC) in Boulder, CO. The data consist of 219 monthly files covering the period 1978–1996 and containing monthly averages of sea ice concentration for both the Northern and Southern Hemispheres.

The term sea ice concentration (SIC) is used to indicate the percentage

- [4] Simmonds, I. H., and T. H. Jacka. 1995. Relationships between the interannual variability of Antarctic sea ice and the Southern Oscillation. Journal of Climate, V8, 637–647.
- [5] Gloersen, P., and W. J. Campbell. 1991. Recent variations in Arctic and Antarctic sea ice covers. Nature, V352, 33–36.

<sup>[3]</sup> Johannessen, O. M., M. Miles, and E. Bjorgo. 1995. The Arctic's shrinking sea ice. Nature, V376, 126–127 (see also http://maui.net/~jstark/ fingerpr.html).

#### **Before You Begin**

These exercises assume that the NASA Image2000 software and the Exercise Data are correctly installed on your system. Refer to the Image2000 Users Guide: Basic Operations for assistance in installing the software. of an ocean area that is covered by ice. A region with no ice has a sea ice concentration of 0%, a region half covered with ice has an ice concentration of 50%, and a region fully covered with ice has an ice concentration of 100%.

For each hemisphere, an image is also provided that contains the land mask for the region and geographic information (lines of latitude and longitude). The Northern and Southern Hemisphere sea ice images and their associated Land Masks are polar sterographic projections; thus, lines of equal latitude appear as concentric circles while lines of equal longitude look like the spokes of a wheel.

#### NASA-Image2000

NASA Image2000 is an image processing software package available on multiple platforms, designed to bring high-end scientific image processing capabilities to the standard desktop computer. Developed to meet the needs of educators, NASA Image2000 supports the display, analysis and processing of satellite imagery.

In the past, users have been forced to choose between software designed for expensive high-end computer systems, and software that lacked many of the tools necessary for performing analysis of satellite images. *NASA Image2000* is designed to provide those tools in a system that is suitable for simple applications, such as would be used in a classroom, but is powerful enough to support serious research.

The functionality built into NASA Image2000 was designed to provide the capability for the display and analysis of geo-coded satellite imagery. The breadth of functionality, however, goes well beyond this scope, and most types of images can be used. Users can perform standard image processing tasks, similar to those available in general graphics packages. In addition, the system provides other less common functions, which are specifically intended for use with scientific images. These exercises provide an introduction both to image processing in general, and to the specific use of NASA Image2000.

#### Loading the Data

All the images and software required for using these lessons are included in the NASA Image2000 CD (v.1.1 or higher). Simply install the software as indicated in the Read Me file on the DC or in the NASA-Image2000 Basic Users Guide (Section 2), located in the doc folder.

#### **Important Notes On Presentation**

Because there are multiple data source possibilities, navigational paths for moving through the hierarchical directory structure of your computer and NASA-Image2000 materials are referenced from the location of your NASA-Image2000 installation. The path is shown as follows:

<i2kinstalled>| data | SEES | <exercise name> | <file name>

In addition, notes, specific tasks and exercises are presented in the left column (see example at left).

#### For Further Research:

## North and South Polar Monthly Sea Ice Concentration Data Set for 1978-1996

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.

#### Characteristics Of The North And South Polar Monthly Sea Ice Concentration Data Set For 1978–1996

Geophysical Measurement:	Sea ice concentration
Units of Measurement:	Percent
Data Source:	Satellites (Nimbus–7 SMMR and DMSP SMMI)
Temporal Resolution:	Monthly averages
Map Projection:	Polar stereographic, both poles
Spatial Resolution:	Nominally 25 km latitude x 25 km longitude
Software Application:	NASA Image2000

#### EXAMPLE

```
...Title of procedure...
```

- 1. Insert ...
- 2. Select ...
- Go to:
  <i2kinstalled>| images | SEES | seaice | psiex1 | nm9603i.tif

4—Click on ...

## How to use the SEES electronic text to support inquiry based exercises

In several of the computer lab exercises, questions will be asked of the user that can not be directly answered through the image analysis software and activites. These questions can be directed to the SEES electronic textbook. This electronic textbook is organized like a printed textbook. It also contains digital files for the graphics that you may either view directly on screen or obtain high-resolution versions for sending to a printer to make color view graphs for overhead projectors. A glossary for each module is also provided. The electronic textbook for each module can also be used to support lecture materials, independant student investigations, or other applications that may require more detailed scientific background.

#### Accessing the SEES electronic textbook

The SEES electronic textbook is available in two locations:

- On the web at http://see.gsfc.nasa.gov/edu/SEES. From the home page, find the link "Class Resources" under the module you are interested in. This will pull up the textbook homepage for that module. Links to each chapter are listed here, leading you to the detailed etext, digital files, and graphics you are searching for.
- 2) On the CD "Studying Earth's Environment from Space, educational materials for students and teachers grades 11-16," available from the NASA CORE (Central Operation of Resources for Education), at http://core.nasa.gov or toll free 866-776-CORE. Once the CD is loaded on your computer, you can access the home page for the etext by going to sees\_v1/htmlpages/ index.html for ozone and global land vegetation modules and sees\_v2/htmlpages/index.html for polar sea ice and oceanography modules.

If you have comments, problems, or suggestions, please e-mail helpdesk@see.gsfc.nasa.gov.

## Exercise 1: Generating North And South Pole Geographic Reference Maps

#### Overview

In this activity you will learn how the north and south polar sea ice concentration data files were named, how to open and display the data files as images using NASA Image2000 (a cross-platform modification of NIH Image), and how to apply a color table to the images. You will also learn how to convert an image's pixel values to actual ice concentrations in percent.

Before working with any data it is important to understand their characteristics. A knowledge of the data type, data source, geophySea Ice Concentrational 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 NASA Image2000, a tool that was developed with the Studying Earth's Environment From Space educational modules in mind.

#### Characteristics Of The North And South Polar Monthly Sea Ice Concentration Data Set For 1978–1996

GeophySea Ice Concentrational Measurement: Sea ice concentration Units of Measurement: Percent

Data Source:	Satellites (Nimbus–7 SMMR and DMSP SMMI)
Temporal Resolution:	Monthly averages
Map Projection:	Polar stereographic, both poles
Spatial Resolution:	Nominally 25 km latitude x 25 km longitude
Software Application:	NASA Image2000

#### Exploring Monthly Sea Ice Concentration At The Poles

There are four types of data files provided here.

- Monthly-average sea ice concentration (sea ice concentration) image files for1978–1996 (219) for the North Pole region
- Monthly-average sea ice concentration image files for1978–1996 (219) for the South Pole region
- Land mask for the North Pole region (1 file)
- Land mask for the South Pole region (1 file)

The first two data types contain monthly-average values of sea ice concentration in percent over the North Pole and South Pole regions, respectively, excluding land. The spatial resolution of these images is approximately 25 square kilometers. This means that each pixel in the image has the equivalent geographic scale of about 25 km x 25 km.

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

#### North Pole monthly average sea ice concentration files for 1978– 1996

#### nmYYMMi.tif

where

YY = last two digits of the year (from 78–96)

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

#### South Pole monthly-average sea ice concentration files for 1978– 1996

#### smYYMMi.tif

where

YY = last two digits of the year (from 78–96)

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

#### North Pole land mask

land\_n.tif

#### South Pole land mask

land\_n.tif

For the sake of quicker, easier downloading, in addition to the entire data set, we've made up special folders that contain only those files you'll need to complete each exercise. Be sure you have the exercise folder you'll be working with installed in

#### <i2kinstalled> | Data | SEES | Sealce

before you begin the exercise.

#### **Opening And Displaying A Sea Ice Concentration Data Image**

#### **Before Beginning**

- Make sure you have read through the Introduction to Module 4: Polar Sea Ice Processes Computer Lab Exercises document.
- Start NASA Image2000, or if it is already running close any open images

#### Exercise 1.A

- Pull down the File menu and choose Open OR click on the Open icon on the toolbar.
- Locate and select this file:
  <I2KInstalled> | data | SEES | Sea\_Ice
  | psiex1 | nm9603i.tif.
- 3. Click on the **Open** button to open the image.
- Pull down the View men and choose Image Info to open the Image Info window.

#### → Do Exercise 1.A now.

You should see this image on your screen, which shows monthly average sea ice concentrations for March 1996.



#### **Answer These Questions:**

- 1. Write down the name of the file you imported.
- 2. Interpret the file name and record the year and month of the sea ice concentration image you displayed.



Year \_\_\_\_\_

#### Adding Color To The Image

To better distinguish the differences in sea ice concentration of the polar regions we can apply color to the image using a color table, also called a color look-up table (LUT), that assigns sea ice concentration values (in percent) to each color.

#### Do Exercise 1.B 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 sea ice concentration in percent.

What colors were assigned to each of the following in the image?

3a. Land: \_\_\_\_\_

3b. Open water: \_\_\_\_\_

3c. 100% (or near 100%) ice covered waters:

Exercise 1.B

Color the image using a Look Up Table (LUT):

1. Pull down the View menu and select Lookup Table (LUT)

The LUT window is displayed.

2. Click on the **Load** button.

The Open File window is displayed.

- Select the LUT you wish to apply, called "Sealce.lut"
- 4. Click on the **Open** button.

The new LUT is displayed in the LUT window, showing you the new RGB display values for each raw pixel value. The image is also updated to display the new values.

5. Click in the Use as default checkbox.

As long as the LUT window is open, this LUT will be applied to future images.

#### **Understanding Display Windows And Images**

If you do not have a North Pole sea ice concentration image open on your screen, open one now. You don't need to apply color to this image. It will look like this. 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. 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.

Close all images now.

#### Creating North And South Pole Geographic Reference Maps

#### Printing Maps

Exercise 1.C

1. Pull down the File menu and select Open. Locate the following file and click Open:

> <i2kinstalled> | Data | SEES | Sea\_lce | psiex1 | land\_n.tif.

- Pull down the File menu and select 2. Print to get a hardcopy of the North Pole land mask.
- Pull down the File menu and select 3. Open. Locate the following file and click Open:

<i2kinstalled> | Data | SEES | Sea\_lce | psiex1 | land\_s.tif.

Pull down the File menu and select 4. Print to get a hardcopy of the South Pole land mask

#### **Overview**

Using books, atlases, and WWW resources at your disposal, create geographic reference maps for the North and South Poles by labeling important geographic features on a printed copy of the Northern Hemisphere and Southern Hemisphere Land Mask.



Refer to hte Polar Ice e-text, Figure 1.c7: html)pages/ polar\_lecure\Part1\1\_Jst1-07.jpg, Fig.1.07 'Arctic locator map'.



#### Do Exercise 1.C now.

Label your maps with geographic features as follows. Once maps are complete, keep your hard copy and close your files.

#### Northern Hemisphere Land Mask

a. Canada	b. Greenland	c. Norway
d. Asia	e. Bering Sea	f. Sea of Okhotsk
g. Barents Sea	h. Greenland Sea	i. Labrador Sea
j. Hudson Bay	k. Norwegian Sea	l. Kara Sea
m. Laptev Sea	n. Chukchi Sea	o. Beaufort Sea
p. Baffin Bay	q. the lines of consta	nt latitude

r. the lines of constant longitude

- s. draw and label with red the warm water currents that flow from the Equator toward the pole
- t. draw and label with blue the cold water currents that flow from the pole toward the Equator



Refer to Polar Lecture, Figure 1.13: html\_pages/ polar\_lecture/Part\_1/1\_Js/1-13.jpg

#### Southern Hemisphere Land Mask

a. East Antarctica	b. West Antarctica	c. Indian Ocean
d. Atlantic Ocean	e. Pacific Ocean	f. Weddell Sea
g. Ross Sea	h. Amundsen Sea	i. Bellinghausen Sea
j. the lines of constant latitude		

- k. the lines of constant longitude
- l. Antarctic Circumpolar Current



Refer to Ocean Lecture, Figure 1.05: html\_pages/ ocean\_lecture/sst\_lecture/Part\_1/1.JS/1.05.jpg

#### The Relationship Between Pixel Value And Sea Ice Concentration Value In Percent

#### Repeat Exercises 1.A and 1.B substituting data file

<i2kinstalled> | data | SEES | seaice | piex1 | sm9608i.tif

#### Answer These Questions:

1. Interpret the file name and record the year and month of the sea ice concentration image you displayed.

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 sea ice concentration values, which range between 0% and 100%, is an important one to understand. Pixel values of 0, 254, and 255 are the only three that do not correspond to an sea ice concentration value in percent. They are always reserved to delineate certain features of an image. For instance, a pixel value of 255 is used for all annotations like the month and year, the border around the image, and the labels on the color legend.

- 2a. Move your cursor over some of the annotations (which are black) and write down the pixel value.
- 2b. What pixel value is associated with land?
- 2c. What pixel value is associated with open water?

- 3a. In the image itself (not the entire Display Window), what do white areas represent?
- 3b. What is the approximate range of pixel values associated with white areas in the image?

The following table contains the pixel values from an sea ice concentration image (we'll call this variable X). Move the cursor along the color legend in the Display Window so that the Pixel Value in the Image Info Window corresponds to each of the pixel values in column X. Read the corresponding sea ice concentration value in percent from the color legend, and write the values in the Y (Ice Concentration) column in the table.

	Х	Y
	Pixel Value	Ice Cencentration (%)
1	17	
2	63	
3	91	
4	120	
5	145	
6	172	
7	215	
8	234	
9	248	

#### Using NASA Image2000 To Calibrate Pixel Values To Sea Ice Concentration Values In Percent



1. Format the display of your Measurement Table:

Pull down the **Image** menu and select **Analysis>Measurement Table**. Then click on the **Options** button, and make sure that only the **Mean** checkbox is checked. Click **OK**.

- Select the image window by clicking in it, and use the Magnifying Glass tool to zoom in on a region until you can easily see individual pixels. Using the Rectangular Selection Tool from the Tools Window, click on a pixel to capture a single pixel area of the image.
- Click on the Measure icon button on the tool bar, or pull down the Image menu and select Analysis>Measure.

Make at least 10 more pixel selections in other parts of the image, choosing a wide range of ice concentrations. After each area is selected, click the Measure icon. Be sure not to include any of the image annotations or land in your small selections.

- Pull down the Image menu and choose Analysis>Measurement Table to view the results. The Measurement Table Window will look something like Figure 1.3, at right. Fill in the table at right with the Mean Pixel Values you selected.
- 6. Use the Unzoom Magnifying Glass to unzoom the image.
- 7. Choose the default mode Arrow.
- Now, move the default arrow tool over the color legend of the image, reading the sea ice concentration values that correspond to the mean pixel values you measured and record these in the table.

The *NASA Image2000* application can automatically calibrate the pixel values of an image with known sea ice concentration values in percent. Please go through the following exercise now so you will be familiar with this process for later explorations.



<i2kinstalled> | data | SEES | seaice | piex1 | sm9608i.tif

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

Month \_\_\_\_\_

Year \_\_\_\_\_



Σ

Do Exercise 1.D now.

	🔲 Image Measurements 🛛 🖉 🖾		Figure 1.3: Mea Table with same	surement ble	
	Delete	Reset	Options	measurements	
Ro.		Mean			
1	245.00				
2	227.00				
3	216.00			Enton walwoo hor	
4	197.00			Enter values her	e.
5	166.00				
6	152.00			Mean Pixel Value	Ice Concentration (%)
7	134.00				. ,
8	126.00				
9	113.00				
10	83.00				
11	60.00				
12	46.00				
13	37.00				
14	25.00				
15	17.00				

#### Exercise 1.F continued...

- Pull down the Image menu and select Properties>Density Calibration. In the dialog box select the Straight Line radio button and type in "percent" for the Unit of Measure.
- 9. Type in the known sea ice concentration values, from the table on the previous page, in the second column of the table in the dialog box.
- 10. Push the Save button and name the file "Ice\_Standards." Be sure you save this file in a place on your hard drive where you'll be able to find it later. This 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 Export. You'll again see the Calibration dialog box.
- 11. Click **Fit Points** 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. (See figure at right.) Answer question 2a-c, then close the plot.
- 12. Click **OK** to apply the Density Calibration to the image.

- 2a. Based on this plot, how well does a straight line describe the relationship between pixel value and ice concentration?
- 2b. What is the slope of this line?
- 2c. What is the intercept of this line?

You may close this plot without saving it. The image has now been calibrated.

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

If you'll 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.

#### Before proceeding to the next exercise,

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

#### TIP

To use a previously saved standards file, follow these steps.

- Pull down the Image menu and select Properties>Density Calibration.
- Select the Straight Line radio button
- Type "percent" in the box titled **Units of Measure**
- Click on the **Open** button, find and select the standards file you saved earlier, and click **OK**.
- Click Fit Points, then close.
- From the Density Calibration window, click **OK**.

## Exercise 2: Observing Northern Hemisphere Sea Ice Distribution And Seasonal Variability

#### **Before Beginning**

- Make sure you have read through the Introduction to Module 4: Expoloring Polar Sea Ice Processes Computer Lab Exercises document.
- Start NASA Image2000, or if it is already running close any open images

#### Exercise 2.A

Make a stack of images

- 1. Pull down the **File** menu and choose **Open** OR Click on the Open icon on the toolbar.
- 2. Locate and select the following file:

<i2kinstalled> | data |SEES | Sea\_lce | psiex2 | 1984 | nm8409i.tif. Click the **Open** button. Repeat for files nm8410i.tif, nm8411i.tif, and nm8412i.tif.

- 3. Pull down the **File** menu and choose **Open** OR Click on the Open icon on the toolbar.
- 4. Locate and select the following directory:

<i2kinstalled> | data |SEES | Sea\_Ice | psiex2 | 1985.

5. Click on the **Open** button to open the images.

The Open Directory dialog opens.

 Select the All Images radio button to open the images, and click on the OK button to continue.

The images are opened as separate images.

 Pull down the Stacks menu and select Windows to Stack>Include All Layers to put all 16 months (one whole year plus the previous fall) in a stack. Use the "slider" tool to move forward and back through the stack.

#### **Overv** iew

This exercise has four sections. In the first three you'll use some of the tools from NASA Image2000 to explore the seasonal variation of SIC in a qualitative, or descriptive manner, where you'll

- Create a stack of images and apply color to them and calibrate them
- Learn to create a movie, called an Animation, from the stack
- Create a Montage of the stack to observe seasonal changes.

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

• Create and plot a time series of SIC using NASA Imgage2000 to collect the time series data.



#### 🛨 Exercise 2.B

Color the stack using a LUT:

- 1. Pull down the View menu and select Lookup Table (LUT)
  - The LUT window is displayed.
- 2. Click on the **Load** button.

The Open File window is displayed.

- 3. Select the LUT you wish to apply, called "Sealce.lut"
- 4. Click on the **Open** button.

The new color LUT will be applied to all images in the stack.

#### 📩 Exercise 2.C

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

- Pull down the Image menu and select Properties>Density Calibration.
- 2. Select the Straight Line radio button
- 3. Type "percent" in the box titled **Units** of Measure
- Click on the **Open** button, and find and locate the calibration file you saved and named Ice\_Standards., and click **Open**.
- 5. Click **Fit Points** and study the relationship between pixel value (x-axis) and sea ice concentration in percent (y-axis). When you are finished, click **Close**.
- 6. From the Density Calibration window, click **OK**.
- **NOTE:** If you don't have the file because you skipped Exercise 1.E, go back and do it now.
- Pull down the View menu and select Image Info to open the Image Info window. You should see Pixel Values listed as % concentration.

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.

# Investigating Seasonal Variations In Sea Ice Concentration From An Animation

#### Overview

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

#### Exercise 2.D

Animate your stack

1. Pull down the **Stack** menu and select **Animate**...

The Animate Stack window is displayed.

- 2. For "quick" animation, accept the default radio button selection of Frames/Second (1-30), and edit the text field to define the speed of the animation (in frames per second).
- 3. Click on the Start button to start the animation.
- 4. Close the Animate Stack window when finished.



#### **Answer These Questions:**



Polar\_Lecture, Part 2, Section 4- Northern Hemisphere.

1a. In what month is the sea ice areal extent a maximum?

1b. In what month is the sea ice areal extent a minimum?

- 2. In general terms, describe how the sea ice extent grows from September 1984 to March 1985. Consider
  - is it a steady growth rate, or does it start growing quickly then more slowly later; or slower at first then more quickly later?
  - where does it start growing?
  - where are the largest initial changes?
- 3. In general terms, describe how the sea ice extent melts and recedes from March 1985 to September 1985. Consider
  - is it a steady melt rate or does it start melting quickly then more slowly later; or slower at first then more quickly later?
  - where does it start melting?
  - where are the largest initial changes?

#### HINT—look at locations of polynyas.



Refer to Polar\_Lecture, Part1, Section 3- Polynyas: Description & Formation Mechanisms

#### Investigating Seasonal Variations In Sea Ice Concentration From A Montage

#### 📩 Exercise 2.E

Make a montage of your stack

1. Pull down the **Stack** menu and select **Montage...**.

The Create Montage window is displayed.

 In the Basic Layout tab, enter "4" for columns and "4" for rows. Then click in the Advanced Layout tab, and enter "1" for increment, and leave the rest at the default. Click OK.

A new untitled montage image window opens, displaying cameos for all 16 images.

 Now experiment. Try entering 4 columns, 2 rows (or 3 columns, 4 rows) in the Basic Layout tab, and 2 for the increment in the Advanced Layout tab. 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 Exercise 2.E now.

Refer to Polar\_Lecture, Part 1: Polar Sea Ice Processes

#### **Answer These Questions:**

1. Describe the sea ice distribution in the Barents and Norwegian Seas in late winter (February–March) and use your North Pole Reference Map (especially the ocean currents you sketched in Exercise 1) to explain it.

2. Compare the sea ice distribution along the east and west coast of Greenland in late winter (north and south and onshore and offshore extents), and use your North Pole Reference Map (especially noticing the ocean currents you sketched) to explain it.

- 3a. Looking at the total annual cycle, where does the ice edge change the most from the summer minimum sea ice extent to the late winter maximum sea ice extent?
- 3b. Where does it change the least?

3c. What is your best explanation for this?

- 4. Describe the marginal ice zone (MIZ) during freeze-up (winter). Consider
  - is it wide
  - is it narrow
  - does the ice concentration vary rapidly or slowly across the MIZ?

#### **Create A Time Series Of The Sea Ice Extent**

The impact of sea ice on the environment would be of little consequence if sea ice were rare. But, the reality is that sea ice extends over a substantial area, mostly in polar regions, of course. At any given time, sea ice covers approximately 25 million square kilometers of Earth's oceans, making it as extensive as the area of the North American continent, which covers about 24.4 million square kilometers. We'll begin studying this by measuring the extent of sea ice for each month in a 16month sequence of images.

## Repeat Exercises 2.B and 2.C for the years 1995 and 1996 (instead of 1984 and 1985).

Position the stack with the earliest September image on top.



Set Scale		X
Image Scaling		
Scaled	🔾 Not Sca	aled
-Scaling Data		
Unit	Kilometers 🔹	
Known Distance	25	
Measured Distance	1	pixels
Pixel Aspect Ratio	1	
Scale 0.04	pixels per	Kilometers
Image Selection		
Scale all images	🔾 Scale C	Current image
	OK Cancel	



Set your measurements

1. Pull down the **Image** menu and select **Properties>Set Scale.** 

The Set Image Scale window opens.

- 2. At the top of the window, click to select the **Scaled** radio button.
- 3. Select Kilometers from the **Unit** pop-up menu.
- 4. Enter "25" for the Known Distance.
- 5. Enter "1" as the **Measured Distance**.
- 6. Make sure that the **Pixel Aspect Ratio** is set to 1 and the Scale reads 0.04.

7. Click OK.



Density slice your stack

1. While viewing the LUT, click on the Slice button.

The Density Slice Editor window is displayed.

- Click on the Color Chooser button. The Color Chooser window is displayed. Click on the Recent Colors block (which should display grey) and click OK. The Density Slice color block in the LUT window should be gray. Close the slice sindow.
- 3. Move the cursor over the color bar in the LUT window until the "hand" tool appears on the grey color block. Click and you will see an up-pointing arrow and a down-pointing arrow on the right of the color block. Using these arrows, click and drag the edge of the color block until it corresponds to a range of ice concentration from about 20% to 100% (read this from the color bar in the image window). See figure at right.
- Pull down the Image menu and select Analysis>Measurement Table. Click on the Options button, and make sure that Area, Mean, and Standard Deviation are selected. Click OK.
- 5. Click on the **Reset** button to clear any previous measurements.
- Activate the Image window, and use the Rectangle Selection Tool and select just the image area as shown in the figure to the right.
- 7. Beginning with the earliest September image, apply click on the Measure icon. You'll see the area, mean, and standard deviation data appear in the Measurement Table window. Use the slider tool to activate the next image and apply the Measure tool to it. Continue through the entire stack in this manner until you gather the information for all 16 months, as shown in the following example.







#### Answer these Questions:

- 1. Record the data from your Results window onto the table on the next page. Since we're working with years 1995–1996 here, add 292,500 to each amount in the Area column and write that down as well (we left enough room for both values).
- 2a. Plot a time series of the sea ice area (as a function of time) for the Arctic region. Plot the month on the X axis and the area on



Average seasonal cycle for the Arctic (from Gloersen et al., 1992)

the Y axis.

2b. What is the minimum areal extent in square kilometers?

2c. What is the maximum areal extent in square kilometers?

- 2d. What is the percent difference?
- Compare your results to the figure below depicting the 1978– 1987 average seasonal cycle determined from SMMR data.
- 3b. Compare your results here to your answers to questions 1a through 3.

- 4a-b. For advance exploration, plot the Mean Percent SIC as well as the Standard Deviation, each as a function of time.
- 4c. What additional information regarding the seasonal changes in the character of the Arctic sea ice cover can you deduce from these plots?

MONTH Years: –	AREA (square kilometers)	MEAN SIC (in percent)	STANDARD DEVIATION (%)
September	-		
October	-		
November	-		
December			
January	-		
February	-		
March	-		
April	-		
May	-		
June	-		
July	-		
August			
September	-		
October	-		
November	-		
December	-		

#### Northern Hemisphere Areal Sea Ice Extent

Add missing data area to column 2 as appropriate — 1,124,375 for years 1979–1987; 292,500 for years 1988–1996

## Exercise 3: Observing Southern Hemisphere Sea Ice Distribution And Seasonal Variability

#### **Before Beginning**

- Make sure you have read through the Introduction to Module 4: Expoloring Polar Sea Ice Processes Computer Lab Exercises document.
- Start NASA Image2000, or if it is already running close any open images

#### Exercise 3.A

Make a stack of images

- Pull down the File menu and choose Open OR Click on the Open icon on the toolbar.
- 2. Locate and select the following directory:

<i2kinstalled> | data |SEES | Sea\_Ice | psiex3 | 1995.

3. Click on the **Open** button to open the images.

The Open Directory dialog opens.

 Select the All Images radio button to open the images, and click on the OK button to continue.

The images are opened as separate images.

- 5. Pull down the **File** menu and choose **Open** OR Click on the Open icon on the toolbar.
- 6. Locate and select the following file:

<i2kinstalled> | data |SEES | Sea\_lce | psiex | 1996 | sm9601i.tif. Click the **Open** button. Repeat for files sm9602i.tif, sm9603i.tif, and sm9604i.tif.

 Pull down the Stacks menu and select Windows to Stack>Include All Layers to put all 16 months (one whole year plus the previous fall) in a stack. Use the "slider" tool to move forward and back through the stack.

#### Overview

This exercise has four sections. In the first three you'll use some of the tools from NASA Image2000 to explore the seasonal variation of sea ice concentration in a qualitative, or descriptive manner, where you'll

- Create a stack of images and apply color to them and calibrate them
- Learn to create a movie, called an Animation, from the stack
- Create a Montage of the stack to observe seasonal changes.

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

Create and plot a time-series of sea ice concentration using NASA Image2000 to collect the time-series data

#### Do Exercises 3.A, 3.B, and 3.C now.

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.



Color the stack using a LUT:

1. Pull down the View menu and select Lookup Table (LUT)

The LUT window is displayed.

2. Click on the **Load** button.

The Open File window is displayed.

- 3. Select the LUT you wish to apply, called "Sealce.lut"
- 4. Click on the **Open** button.

The new color LUT will be applied to all images in the stack.



#### Exercise 3.C

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

- Pull down the Image menu and select Properties>Density Calibration.
- 2. Select the Straight Line radio button
- 3. Type "percent" in the box titled **Units** of Measure
- Click on the **Open** button, and find and locate the calibration file you saved and named Ice\_Standards., and click **OK**.
- 5. From the Density Calibration window, click **OK**.
- **NOTE:** If you don't have the file because you skipped Exercise 1.E, go back and do it now.

## Investigating Seasonal Variations In Sea Ice Concentration From An Animation

#### Exercise 3.D

Animate your stack

1. Pull down the **Stack** menu and select **Animate**...

The Animate Stack window is displayed.

- For "quick" animation, accept the default radio button selection of Frames/Second (1-30), and edit the text field to define the speed of the animation (in frames per second).
- Click on the Start button to start the animation.

#### Overview

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



#### **Answer These Questions:**



Refer to Polar\_Lecutres, Part 1, Section 3, "Polynyas:Description & Fermatia Mechanics", and Section 5, "Southern Hemisphere"

1a. In what month is the sea ice areal extent a maximum?

1b. In what month is the sea ice areal extent a minimum?

- 2. In general terms, describe how the sea ice extent grows from February 1995 to September 1995. Consider
  - is it a steady growth rate, or does it start growing quickly then more slowly later; or slower at first then more quickly later?
  - where does it start growing?
  - where are the largest initial changes?
- 3. In general terms, describe how the sea ice extent melts and recedes from September 1995 to April 1996. Consider
  - is it a steady melt rate or does it start melting quickly then more slowly later; or slower at first then more quickly later
  - where does it start melting?
  - where are the largest initial changes?
  - what significant event takes place in the Ross Sea in approximately November or December.

#### Investigating Seasonal Variations In Sea Ice Concentration From A Montage

#### Exercise 3.E

Make a montage of your stack

1. Pull down the **Stack** menu and select **Montage...**.

The Create Montage window is displayed.

 Enter "4" for columns, "4" for rows, "1" for increment, and leave the rest at the default.

A new untitled montage image window opens, displaying cameos for all 16 images.

 Now experiment. Try entering 4 columns, 2 rows (or 3 columns, 4 rows), and 2 for the increment. This will display a montage of every other month, and each cameo will be larger.

#### → Do Exercise 3.E now.

#### Answer These Questions:

- 1. Describe the marginal ice zone (MIZ) during freeze-up (winter). Consider
  - is it wide
  - is it narrow
  - does the ice concentration vary rapidly or slowly across the MIZ?
- 2. If you completed Exercise 2, compare this Antarctic MIZ to that of the Arctic region.

Close this stack.

#### **Create A Time Series Of The Sea Ice Extent**

#### Overview

The impact of sea ice on the environment would be of little consequence if sea ice were rare. But, the reality is that sea ice extends over a substantial area, mostly in polar regions, of course. At any given time, sea ice covers approximately 25 million square kilometers of Earth's oceans, making it as extensive as the area of the North American continent, which covers about 24.4 million square kilometers. We'll begin studying this by measuring the extent of sea ice for each month in a 16month sequence of images.



#### Repeat Exercises 3.B and 3.C.

Do Exercise 3.F now.

Position the stack with the earliest January image on top.

#### Exercise 3.F

Set your measurements

1. Pull down the **Image** menu and select **Properties>Set Scale.** 

The Set Image Scale window opens.

- 2. Select Kilometers from the **Unit** pop-up menu.
- 3. Enter "25" for the Known Distance.
- 4. Enter "1" as the Measured Distance.
- 5. Make sure that the **Pixel Aspect Ratio** is set to 1 and the Scale reads 0.04.

6. Click OK.

Set Scale		X
Image Scaling		
Scaled	🔿 Not Sca	lled
Scaling Data		
Unit	Kilometers 🔹	
Known Distance	25	
Measured Distance	1	pixels
Pixel Aspect Ratio	1	
Scale 0.04	pixels per	Kilometers
Image Selection		
Scale all images	O Scale C	urrent image
	OK Cancel	

#### **Exercise 3.G**

Density slice your stack

1. While viewing the LUT, click on the Slice button.

The Density Slice Editor window is displayed.

- Click on the Color Chooser button. The Color Chooser window is displayed. Click on the Recent Colors block (which should display grey) and click OK. The Density Slice color block in the LUT window should be gray. Close the slice sindow.
- 3. Move the cursor over the color bar in the LUT window until the "hand" tool appears on the grey color block. Click and you will see an up-pointing arrow and a down-pointing arrow on the right of the color block. Using these arrows, click and drag the edge of the color block until it corresponds to a range of ice concentration from about 15% to 100% (read this from the color bar in the image window).

When you slick your stack, do not include land in your selection! To insure you will only measure ice concentration, you may type in the Start Index and End Index as shown in the figure at right (101.15 and 14.99 respectively).

- Pull down the Image menu and select Analysis>Measurement Table. Click on the Options button, and make sure that Area, Mean, and Standard Deviation are selected. Click OK.
- 5. Click on the **Reset** button to clear any previous measurements.
- Activate the Image window, and use the Rectangle Selection Tool and select just the image area.
- 7. Beginning with the earliest September image, apply click on the Measure icon. You'll see the area, mean, and standard deviation data appear in the Measurement Table window. Use the slider tool to activate the next image and apply the Measure tool to it. Continue through the entire stack in this manner until you gather the information for all 16 months, as shown in the following example.

#### → Do Exercise 3.G now.





#### Answer These Questions

1. Record the data from your Results window onto the table on the next page.

MONTH Years: –	AREA (square kilometers)	MEAN SIC (in percent)	STANDARD DEVIATION (%)
January			
February	-		
March			
April	-		
May			
June	-		
July	-		
August	-		
September			
October	-		
November			
December			
January	-		
February			
March			
April			

#### Southern Hemisphere Areal Sea Ice Extent

- 2a. Plot a time series of the sea ice area (as a function of time) for the Antarctic region. Plot the month on the X axis and the area on the Y axis.
- 2b. What is the minimum areal extent in square kilometers?

<sup>2</sup>c. What is the maximum areal extent in square kilometers?

- 2d. What is the percent difference?
- 2e. How does this compare with the Arctic?

3a. Compare your results to the figure below depicting the 1978–1987 average seasonal cycle determined from SMMR data.



Average seasonal cycle for the Antarctic (from Gloersen et al., 1992)

3b. Compare your results here to your answers to questions 1a - 3. Does this more quantitative analysis improve the quality of your earlier answers and your confidence in those answers?

- 4. Compare the shape or trends seen in the Arctic and Antarctic time series you created and comment on differences in the seasonal cycles of each.
- 5a-b. For advance exploration, plot the Mean Percent sea ice concentration as well as the Standard Deviation, each as a function of time.
- 5c. What additional information regarding the seasonal changes in the character of the Antarctic sea ice cover can you deduce from these plots?

# Exercise 4: Qualitative Tools For Exploring The Interannual Variability Of Arctic Sea Ice Distribution

#### **Before Beginning**

- Make sure you have read through the Introduction to Module 4: Expoloring Polar Sea Ice Processes Computer Lab Exercises document.
- Start NASA Image2000, or if it is already running close any open images
- Exercise 4.A

Make a stack of images

- 1. Pull down the **File** menu and choose **Open** OR Click on the Open icon.
- 3. Locate and select the following directory:

<*i2kinstalled*> | data |SEES | Sea\_Ice | psiex4| maximums.

4. Click on the **Open** button to open the images.

The Open Directory dialog opens.

 Select the Stack radio button to open the images, and click on the OK button to continue.

The images are opened in a stack. Use the "slider" tool to move through the stack.

#### Exercise 4.B

Color the stack using a LUT:

1. Pull down the View menu and select Lookup Table (LUT)

The LUT window is displayed.

- Click on the Load button. The Open File window is displayed.
- 3. Select the LUT you wish to apply, called "Sealce.lut"
- Click on the **Open** button.
  The new color LUT will be applied to all images in the stack.

#### Overview

Use the results from Exercise 2 to help you answer this question.

1. In the Northern Hemisphere, which month of the year typically shows the maximum sea ice extent?



Do Exercise 4.A and 4.B now.



#### Choose and perform either Exercise 4.C or 4.D.

Using either your animation or montage, visually inspect the general interannual variability in the Northern Hemisphere sea ice distribution.

#### Answer These Questions.

Which years had the largest ice extent in the

- Barents Sea 2a. Bering Sea 2b. Sea of Okhotsk 2c. 2d. Labrador Sea 2e. Greenland-Norwegian Seas Which years had the smallest ice extent in the 3a. Barents Sea Bering Sea \_\_\_\_\_ 3b. Sea of Okhotsk 3c. 3d. Labrador Sea \_\_\_\_\_
- 3e. Greenland-Norwegian Seas \_\_\_\_\_

4.

#### Exercise 4.C

Animate your stack

1. Pull down the **Stack** menu and select **Animate**...

The Animate Stack window is displayed.

- For "quick" animation, accept the default radio button selection of Frames/Second (1-30), and edit the text field to define the speed of the animation (in frames per second).
- 3. Click on the Start button to start the animation.
  - Exercise 4.D

Use the stack another way

- Pull down the Image menu and select Analyze >Measurement Table. If the table contains data, click on the Reset button.
- 2. Use the Rectangle Selection Tool and draw a box around a specific area of interest.



3. Step through the images one at a time gaging the amount of ice showing up in the box. It's fairly easy to see which images have lots of ice in the region and which ones don't. Then jot down the year.

From these qualitative observations, do you observe or can you conclude anything in regard to any long-term trend in the extent of sea ice in the Northern Hemisphere?

Leave the March (maximum sea ice concentration) images open.

# Quantitative Tools For Exploring The Interannual Variability Of Arctic Sea Ice Distribution

#### Exercise 4.E

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

- 1. Pull down the **Image** menu and select **Properties>Density** Calibration.
- 2. Select the Straight Line radio button
- 3. Type "percent" in the box titled **Units** of Measure
- Click on the **Open** button, and find and locate the calibration file you saved and named Ice\_Standards., and click **OK**.
- 5. From the Density Calibration window, click **OK**.
- NOTE: If you don't have the file because you skipped Exercise 1.E, go back and do it now.

#### Exercise 4.F

Set your measurements

1. Pull down the **Image** menu and select **Properties>Set Scale**.

The Set Image Scale window opens.

- 2. Click on the **Scaled** radio button.
- 3. Select Kilometers from the **Unit** pop-up menu.
- 4. Enter "25" for the Known Distance.
- 5. Enter "1" as the **Measured Distance**.
- Make sure that the Pixel Aspect Ratio is set to 1 and the Scale reads 0.04.
- 7. Click OK.

#### Overview

In this activity you'll quantitatively explore two questions regarding the interannual variation in the areal extent of the Northern Hemisphere sea ice cover. First, what is the interannual variability in the maximum extent of sea ice? Second, what is the interannual variability in the extent of the Northern Hemisphere permanent sea ice cover; i.e., variability in the minimum areal extent?

Calibrate the stack of "maximum" sea ice images, then use the Density Slice tool to find the sea ice areal extent for each sea ice maximum (March) image in your stack for all 18 years and make plots to use in analysis.



Do Exercises 4.E, 4.F, and 4.G.

Set Scale	×
-Image Scaling	
Scaled	O Not Scaled
Scaling Data	
Unit	Kilometers 💌
Known Distance	25
Measured Distance	1 pixels
Pixel Aspect Ratio	1
Scale 0.04	pixels per Kilometers
Image Selection	
Scale all images	Scale Current image
[	OK Cancel

#### Exercise 4.G

Density slice your stack

1. While viewing the LUT, click on the Slice button.

The Density Slice Editor window is displayed.

- Click on the Color Chooser button. The Color Chooser window is displayed. Click on the Recent Colors block (which should display grey) and click OK. The Density Slice color block in the LUT window should be gray. Close the slice sindow.
- 3. Move the cursor over the color bar in the LUT window until the "hand" tool appears on the grey color block. Click and you will see an up-pointing arrow and a down-pointing arrow on the right of the color block. Using these arrows, click and drag the edge of the color block until it corresponds to a range of ice concentration from about 15% to 100% (read this from the color bar in the image window). Or, enter 100.36 in the Start Index window of the Density Slice editor and 14.99 in the End Index window.
- Pull down the Image menu and select Analyze>Measurement Table. Click on the Options button, and make sure that Area, Mean, and Standard Deviation are selected. Click OK.
- 5. Click on the **Reset** button to clear any previous measurements.
- 6. Activate the Image window, and use the Rectangle Selection Tool and select just the image area.
- 7. Beginning with March 1979 image, click on the Measure icon. You'll see the area, mean, and standard deviation data appear in the Measurement Table window. Use the slider tool to activate the next image and apply the Measure tool to it. Continue through the entire stack in this manner until you gather the information for all 16 months, as shown in the following example.





#### **Answer These Questions:**

1. Record the data from your Results window onto the table on the next page. Add the appropriate missing data amount to each amount in the Area column and write that down as well (we left enough room for both values).

YEAR Month:	AREA (square kilometers)	MEAN SIC (in percent)	STANDARD DEVIATION (%)
1979			
1980			
1981	-		
1982			
1983	-		
1984			
1985	-		
1986			
1987			
1988	-		
1989			
1990	-		
1991	-		
1992			
1993			
1994	-		
1995	-		
1996			

#### Northern Hemisphere Areal Sea Ice Extent Maximums

Add up the area amounts for each year and divide by 18 to find the average sea ice concentration maximum. This average is called the Climatological Mean for the period you're studying. Compare this average to the maximum ice extent for each year.

- 2a. What is the Climatological Mean for maximum sea ice concentration?
- 2b. Do any years stand out as being greater or less than the Climatological Mean? List them here.

3a-c. Now create plots of the maximum sea ice extent and the mean functions of time. On the plot of maximum sea ice extent, plot the climatological average you computed. Do this either by hand or use a software package, such as Excel. Be certain to label all of your axes and give each plot a title.

4a. Which years had the largest maximum sea ice areal extent?

4b. Which years had the smallest maximum sea ice areal extent?

4c. What is the percent difference between them?

5. Do a best fit line to your maximum sea ice extent time series. Again, you can do this either by hand, or use a software package, such as Excel. Is there any long-term trend evident? Explain.

6. What additional information regarding interannual changes in the character of the maximum ice cover of the Arctic can you deduce from the mean percent sea ice concentration and the standard deviation time series?

Now we'll perform the same procedures on the 18-years' minimums. Checking your results from Exercise 2,

7. in the Northern Hemisphere, which month of the year typically shows the minimum sea ice extent?



#### Do Exercises 4.B, 4.E, and 4.F using the data from

<i2kinstalled> | data | SEES | Sea\_Ice | piex4 | minimums

#### **Exercise 4.H**

Density slicing continued on part of your stack

- Use the Rectangle Selection Tool to select just the northernmost reaches of the image from within the display window. See figure at right.
- 2 Pull down the Image menu and select Analyze>Measurement Table, and click the Reset button to clear any previous results.
- 3. Beginning with the earliest September image, apply click on the Measure icon. You'll see the area, mean, and standard deviation data appear in the Measurement Table window. Use the slider tool to activate the next image and click Measure. Continue through the entire stack in this manner until you gather the information for all 18 years, as shown in the following example.

#### $\rightarrow$

#### Do Exercise 4.G, steps 1–7 only then skip to Exercise 4.H.

8. Record the data from the Results Window onto the table on the next page, adding the missing data region amounts.



The reason we don't want to compute the areal extent based on the entire image is because of something called "land contamination;" when the satellite data for the ocean are being contaminated by having some radiation from the land mixed in with that from the ocean. For that reason, the halo of colors around the land boundaries should be ignored, as the sea ice calculations are not reliable adjacent to land. Obviously, there is no sea ice in the Great Lakes in September.

YEAR Month:	AREA (square kilometers)	MEAN SIC (in percent)	STANDARD DEVIATION (%)
1979	-		
1980	-		
1981	-		
1982	-		
1983			
1984	-		
1985			
1986			
1987	-		
1988			
1989	-		
1990			
1991			
1992	-		
1993	-		
1994			
1995			
1996			

Northern Hemisphere Areal Sea Ice Extent Minimums

Add up the adjusted area amounts for each year and divide by 18 to find the average sea ice concentration minimum: the Climatological Mean for the period you're studying. Compare this average to the minimum ice extent for each year.

- 9a. What is the Climatological Mean for minimum sea ice concentration?
- 9b. Do any years stand out as being greater or less than the Climatological Mean? List them here.

10a-c. Now create plots of the minimum sea ice extent and the mean as functions of time. On the plot of minimum sea ice extent, plot the climatological average you computed. Do this either by hand or use a software package, such as Excel. Be sure to label all of your axes and give each plot a title.

11a. Which year was the permanent ice cover the largest?

- 11b. Which year was the permanent ice cover the smallest?
- 11c. What is the percent difference between the two years?
- 12. Do a best fit line to your minimum sea ice extent time series. Again, you can do this either by hand, or use a software package, such as Excel. Is there any long-term trend evident? Explain.
- 13. What additional information regarding interannual changes in the character of the permanent ice cover of the Arctic can you deduce from the mean percent sea ice concentration and the standard deviation time series?

Compare the results of your maximum and minimum sea ice areal extent time series with this figure.

### Exercise 5: Qualitative Tools For Exploring The Interannual Variability Of Antarctic Sea Ice Distribution

#### Exercise 5.A

Make a stack of images

- 1. Pull down the **File** menu and choose **Open** OR Click on the Open icon on the toolbar.
- 3. Locate and select the following directory:

<*i2kinstalled*> | data |SEES | Sea\_Ice | psiex5 | maximums.

4. Click on the **Open** button to open the images.

The Open Directory dialog opens.

5. Select the **Stack** radio button to open the images, and click on the **OK** button to continue.

The images are opened in a stack. Use the "slider" tool to move forward and back through the stack.

#### Exercise 5.B

Color the stack using a LUT:

1. Pull down the View menu and select Lookup Table (LUT)

The LUT window is displayed.

2. Click on the Load button.

The Open File window is displayed.

- Select the LUT you wish to apply, called "Sealce.lut"
- 4. Click on the **Open** button.

The new color LUT will be applied to all images in the stack.

#### Overview

Use the results from Exercise 2 to help you answer this question.

1. In the Southern Hemisphere, which month of the year typically shows the maximum sea ice extent?



Choose and perform either Exercise 5.C or Exercise 5.D.

Using either your animation or montage, visually inspect the general interannual variability in the Southern Hemisphere sea ice distribution.

2. From these qualitative observations, do you observe or can you conclude anything in regard to any long-term trend in the extent of sea ice in the Southern Hemisphere?

Leave this stack open.



Animate your stack

1. Pull down the **Stack** menu and select **Animate**...

The Animate Stack window is displayed.

- 2. For "quick" animation, accept the default radio button selection of Frames/Second (1-30), and edit the text field to define the speed of the animation (in frames per second).
- 3. Click on the Start button to start the animation.

#### Exercise 5.D

Use the stack another way

- Pull down the Image menu and select Analyze >Measurement Table. If the table contains data, click on the Reset button.
- 2. Use the Rectangle Selection Tool and draw a box around a specific area of interest.
- Step through the images one at a time gaging the amount of ice showing up in the box. It's fairly easy to see which images have lots of ice in the region and which ones don't. Then jot down the year.

# Quantitative Tools For Exploring The Interannual Variability Of Antarctic Sea Ice Distribution

#### Exercise 5.E

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

- 1. Pull down the **Image** menu and select **Properties>Density Calibration**.
- 2. Select the **Straight Line** radio button
- 3. Type "percent" in the box titled **Units of Measure**
- 4. Click on the **Open** button, and find and locate the calibration file you saved and named Ice\_Standards., and click **OK**.
- 5. From the Density Calibration window, click **OK**.
- **NOTE:** If you don't have the file because you skipped Exercise 1.E, go back and do it now.



Set your measurements

1. Pull down the **Image** menu and select **Properties>Set Scale.** 

The Set Image Scale window opens.

- 2. Click the Scaled radio button.
- 3. Select Kilometers from the **Unit** pop-up menu.
- 4. Enter "25" for the Known Distance.
- 5. Enter "1" as the **Measured Distance**.
- 6. Make sure that the **Pixel Aspect Ratio** is set to 1 and the Scale reads .04.

7. Click OK.

#### Overview

In this activity you'll quantitatively explore two questions regarding the interannual variation in the areal extent of the Southern Hemisphere sea ice cover. First, what is the interannual variability in the maximum extent of sea ice? Second, what is the interannual variability in the extent of the Southern Hemisphere permanent sea ice cover; i.e., variability in the minimum areal extent?

Use the stack you created in 5.A-5.D. Use the Density Slice tool to find the sea ice areal extent for each sea ice maximum (September) image in your stack for all 18 years and make plots to use in analysis.



Set Scale		×	
Image Scaling			
Scaled	O Not Sca	lled	
Unit	Kilometers 💌		
Known Distance	25		
Measured Distance	1	pixels	
Pixel Aspect Ratio	1		
Scale 0.04	pixels per	Kilometers	
Image Selection			
Scale all images  O Scale Current image			
[	OK Cancel	]	

#### **Exercise 5.G**

Density slice your stack

1. While viewing the LUT, click on the Slice button.

The Density Slice Editor window is displayed.

- Click on the Color Chooser button. The Color Chooser window is displayed. Click on the Recent Colors block (which should display grey) and click OK. The Density Slice color block in the LUT window should be gray. Close the slice sindow.
- 3. Move the cursor over the color bar in the LUT window until the "hand" tool appears on the grey color block. Click and you will see an up-pointing arrow and a down-pointing arrow on the right of the color block. Using these arrows, click and drag the edge of the color block until it corresponds to a range of ice concentration from about 15% to 100% (read this from the color bar in the image window). Or, enter 100.36 in the Start Index field and14.99 in the End Index field of the Density Slice Editor.
- Pull down the Image menu and select Analyze>Measurement Table. Click on the Options button, and make sure that Area, Mean, and Standard Deviation are selected. Click OK.
- 5. Click on the **Reset** button to clear any previous measurements.
- 6. Activate the Image window, and use the Rectangle Selection Tool and select just the image area.
- 7. Beginning with the earliest September image, apply click on the Measure icon. You'll see the area, mean, and standard deviation data appear in the Measurement Table window. Use the slider tool to activate the next image and apply the Measure tool to it. Continue through the entire stack in this manner until you gather the information for all 16 months, as shown in the following example.





#### Answer These Questions

1. Record the data from your Results window onto the table on the next page.

YEAR Month:	AREA (square kilometers)	MEAN SIC (in percent)	STANDARD DEVIATION (%)
1979			
1980			
1981			
1982			
1983			
1984			
1985			
1986			
1987			
1988			
1989			
1990			
1991			
1992			
1993			
1994			
1995			
1996			

#### Southern Hemisphere Areal Sea Ice Extent Maximums

Add up the area amounts for each year and divide by 18 to find the average sea ice concentration maximum. This average is called the Climatological Mean for the period you're studying. Compare this average to the maximum ice extent for each year.

2a. What is the Climatological area mean for maximum sea ice areal extent?

- 2b. Do any years stand out as being greater or less than the Climatological Mean? List them here.
- 3a-c. Now create plots of the maximum sea ice extent, the mean, and the standard deviation as functions of time. On the plot of maximum sea ice extent, plot the climatological average you computed. Do this either by hand or use a software package, such as Excel. Be certain to label all of your axes and give each plot a title.
- 4a. Which years had the largest maximum sea ice areal extent?
- 4b. Which years had the smallest maximum sea ice areal extent?

4c. What is the percent difference between them?

- 5. Do a best fit line to your maximum sea ice extent time series. Again, you can do this either by hand, or use a software package, such as Excel. Is there any long-term trend evident? Explain.
- 6. What additional information regarding interannual changes in the character of the maximum ice cover of the Antarctic can you deduce from the mean percent sea ice concentration and the standard deviation time series?

Now we'll perform the same procedures on the 18-years' minimums. Checking your results from Exercise 2, 7. In the Southern Hemisphere, which month of the year typically shows the minimum sea ice extent? \_



#### Do Exercises 5.B, 5.E, 5.F, and 5.G using the data from

<i2kinstalled> | data | SEES | Sea\_Ice | piex5 | minimums



YEAR Month:	AREA (square kilometers)	MEAN SIC (in percent)	STANDARD DEVIATION (%)
1979			
1980			
1981			
1982			
1983			
1984			
1985			
1986			
1987			
1988			
1989			
1990			
1991			
1992			
1993			
1994			
1995			
1996			

Southern Hemisphere Areal Sea Ice Extent Minimums

8. Record the data from the Results Window onto the table on the next page.

Add up the amounts for each year and divide by 18 to find the average sea ice concentration minimum: the Climatological Mean for the period you're studying. Compare this average to the minimum ice extent for each year.

9a. What is the Climatological Mean for minimum sea ice concentration?

- 9b. Do any years stand out as being greater or less than the Climatological Mean? List them here.
- 10a-c. Now create plots of the minimum sea ice extent, the mean, and the standard deviation as functions of time. On the plot of minimum sea ice extent, plot the climatological average you computed. Do this either by hand or use a software package, such as Excel. Be sure to label all of your axes and give each plot a title.
- 11a. Which year was the permanent ice cover the largest?
- 11b. Which year was the permanent ice cover the smallest?
- 11c. What is the percent difference between the two years?
- 12. Do a best fit line to your minimum sea ice extent time series. Again, you can do this either by hand, or use a software package, such as Excel. Is there any long-term trend evident? Explain.
- 13. What additional information regarding interannual changes in the character of the permanent ice cover of the Antarctic can you deduce from the mean percent sea ice concentration and the standard deviation time series?

Compare the results of your afficient fining and the series with this figure [1]

