

exploring polar sea ice processes using satellite data

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 *SEE Image*, 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 view-graphs 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 is difficult to dis-

[1] Washington, W. M., and G. A. Meehl. 1989. Climate sensitivity due to increased CO₂: experiments with a coupled atmosphere and ocean general circulation model. *Climate Dynamics*, V4, 1–38.

tinguish the natural variations of the ice from any enhanced greenhouse melting. In fact, it has 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 short-term 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 (SSM/I). These data are produced by the Laboratory for Hydrospheric Processes at the

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- [2] 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.
- [3] 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>).
- [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.

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.

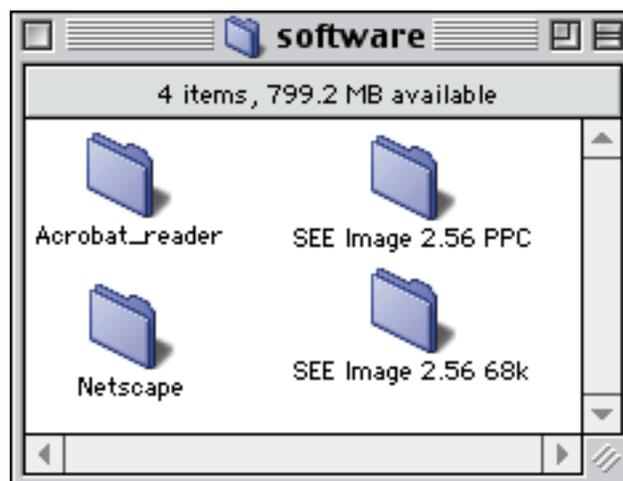
The term *sea ice concentration* (SIC) is used to indicate the percentage of an ocean area that is covered by ice. A region with no ice has a sea ice concentration of 0%, a region half covered with ice has an ice concentration of 50%, and a region fully covered with ice has an ice concentration of 100%.

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 stereographic projections; thus, lines of equal latitude appear as concentric circles while lines of equal longitude look like the spokes of a wheel.

getting started

Before you begin to work on these exercises you'll need to install *SEE Image*, have the data you'll need for these exercises loaded and organized, and make sure your computer and software are set up correctly.

SEES CD users, double click the CD's icon, then double click the Software folder.



Choose the SEE Image version that matches your computer type and drag that folder onto your hard drive.

SEES Web site users, go to

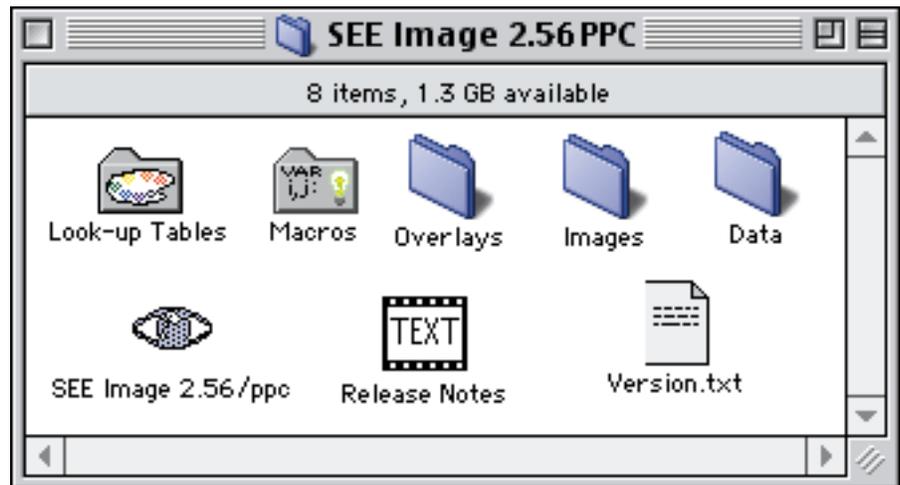
<http://see.gsfc.nasa.gov/edu/SEES/>

Under **Polar Ice Processes**, click **Computer Lab Resources** then click **Software**. Downloading instructions are given on the site. Follow them, then sit back and relax while the file downloads. Once the download is complete, the following icons will appear on your desktop.



NOTE: The software is updated occasionally. The number after "SEE Image" indicates the version. Check the Web site periodically for the latest version.

You now have a folder labeled **SEE Image** on your desktop that contains the program (whose icon is an eye), some Release Notes, a "version.txt" file, and five folders. Drag that folder onto your hard drive.



SEE Image is a modified version of NIH Image (<http://rsb.info.nih.gov/nih-image/Default.html>). To use the various functions necessary for the exercises, *SEE Image* must be configured properly. Instructions for configuration are given at the start of each exercise. If you are unfamiliar with *SEE Image*, please work through these exercises in order, from one through five. If you and your students are familiar with NIH Image or *SEE Image* and do not need a complete tutorial, each exercise may be used as a “stand-alone” unit.

loading the data

Navigational paths for moving through the hierarchical directory structure of your computer and *SEE Image* materials appear as follows:

Desktop | your hard drive (HD) | the main SEE Image folder | next item of choice | etc.

SEES CD users, go to

Desktop | SEES CD | data

then click and drag the data folder for the chosen exercise into

Desktop | HD | SEE Image | Data | Sea_Ice

It's very important that you put the data in this directory because all instructions use this path.

SEES Web site users, go to

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

Under **Polar Ice Processes**, click **Computer Resources**. Then click **Data** and click on the data sets you want. When the download is complete and the archive is unpacked, which will occur automatically, you'll see three new icons on your desktop for each set of data you downloaded. Two are document icons that will have one of these file name extensions: **.sea.hqx** or **.sea**. You may trash those files. The third is a folder icon. Drag that folder into the "Sea_Ice" folder as described above.

setting up your computer

Pull down the  menu, choose **Control Panels** then choose **Monitors & Sound (Monitors)** and set the colors to "thousands" or "millions."

If your hardware doesn't offer this option, you can still run SEE Image using 255 colors, but your desktop colors may change. It's not permanent. Your desktop colors will reset to your original choices when you quit SEE Image.

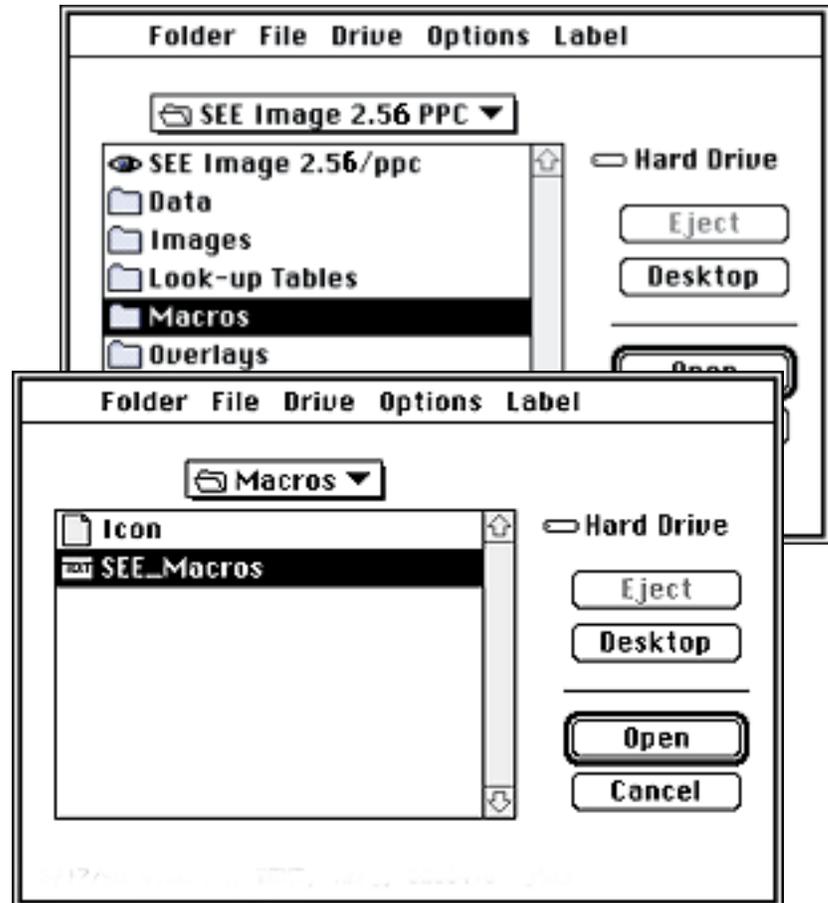
SEE Image will install with just enough memory allocated (~11 MB) to run the exercises. If you want to import more images than those used in these exercises, you'll need to increase this amount or you'll get error messages while loading or creating images. To increase the memory, click once on the SEE Image icon to highlight it, pull down the **FILE** menu and choose **Get Info**. Increase the number in the Preferred Size box at the bottom right.

NOTE: Even if you don't get error messages, it's a good idea to increase the memory allocation if you have enough available. All software works better and often faster with more room to move.

loading the see image macros

Special programs called macros were designed specifically for working with sea ice concentration data. Macros either perform specific tasks unavailable in the original software or automate a series of steps that are tedious if performed manually.

Pull down **SPECIAL** and choose **Load Macros**. Highlight and **Open** as shown.



NOTE: You'll have to load the macros every time you start *SEE Image*.

Comprehensive *SEE Image* tutorials were developed for Total Ozone Concentration and Global Land Vegetation data and are available from the Studying Earth's Environment From Space Web site: <http://see.gsfc.nasa.gov/edu/SEES/>. These tutorials may also serve as reference manuals for processing images for incorporation into another document or for exporting data into another application. They provide more detailed instructions for some operations than are found in these exercises.

list of exercises

Exercise 1—Generating North and South Pole Geographic Reference Maps

- File type and file name description
- Opening and displaying sea ice concentration (SIC) data images
- Adding color to the images
- Understanding display windows and images
- Creating North and South Pole geographic reference maps
- Using *SEE Image* to calibrate pixel values to SIC in percent

Exercise 2—Observing Northern Hemisphere Sea Ice Distribution and Seasonal Variability

- Qualitative tools for exploring the sea ice distribution of the Arctic
 - Configure *SEE Image*
 - Create a stack, apply the *SEAICE LUT*, and calibrate the image
 - Use animation to investigate seasonal variations in SIC
 - Use a montage to investigate seasonal variations in SIC
- Quantitative tools for exploring the sea ice distribution of the Arctic
 - Create a time series of sea ice areal extent
 - Calculate growth and decay rates of sea ice

Exercise 3—Observing Southern Hemisphere Sea Ice Distribution and Seasonal Variability

- Qualitative tools for exploring sea ice distribution of the Antarctic
 - Configure *SEE Image*
 - Create a stack, apply the *SEAICE LUT*, and calibrate the image
 - Use animation to investigate seasonal variations in SIC
 - Use a montage to investigate seasonal variations in SIC
- Quantitative tools for exploring sea ice distribution of the Antarctic
 - Create a time series of sea ice areal extent
 - Calculate growth and decay rates of sea ice

Exercise 4—Observing Northern Hemisphere Interannual Variability

- Qualitative tools for exploring the interannual variability of Arctic sea ice distribution
- Quantitative tools for exploring the interannual variability of Arctic sea ice distribution
 - Maximum sea ice extent
 - Minimum sea ice extent

Exercise 5—Observing Southern Hemisphere Interannual Variability

- Qualitative tools for exploring the interannual variability of Antarctic sea ice distribution
- Quantitative tools for exploring the interannual variability of Antarctic sea ice distribution
 - Maximum sea ice extent
 - Minimum sea ice extent