OBJECTIVES

PART I Learn how to project/specify projection of an image in SeaDAS

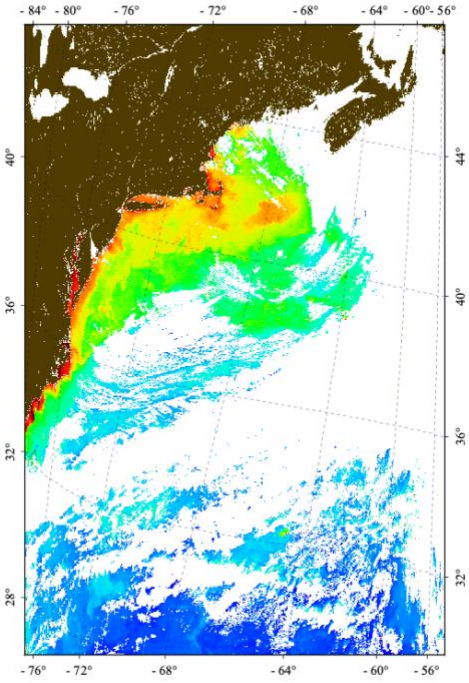
PART II Learn how to utilize masks and extract data

PART I: PROJECTING AN IMAGE

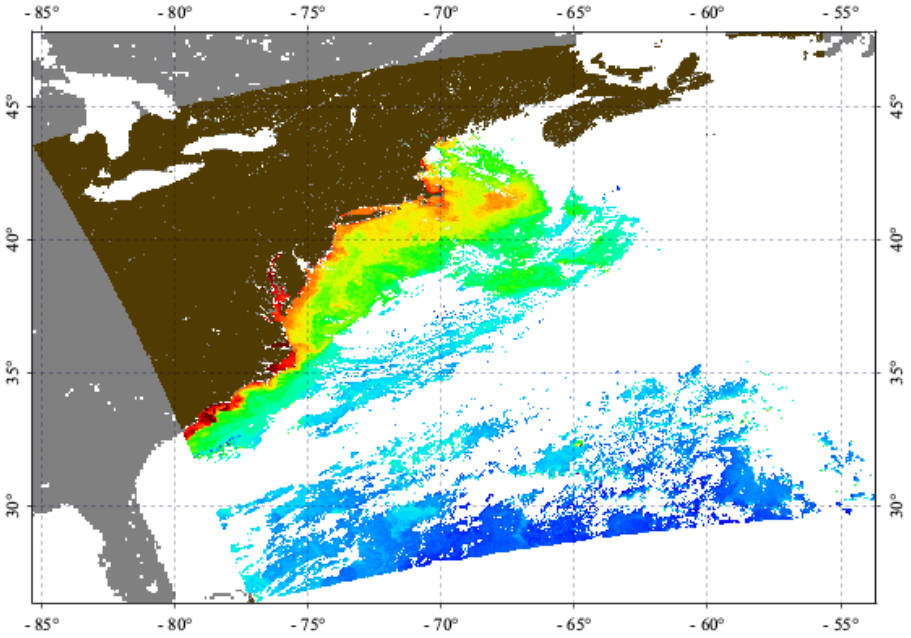
Before you start this section, make sure to download the L2 files, AQUA_MODIS.20151215T174001.L2.OC.nc and AQUA_MODIS.20151231T210001.L2.OC.nc from canvas or the course website (in the L2 directory of Lab2). You will also be using these files for Lab 3 next week.

By projecting an image, you can create evenly gridded maps of data within a specific area. Depending on where you are in the world, certain map projections are more or less appropriate.

Here's an unprojected image you will process in this lab. Notice how the gridlines are unevenly space and curved:

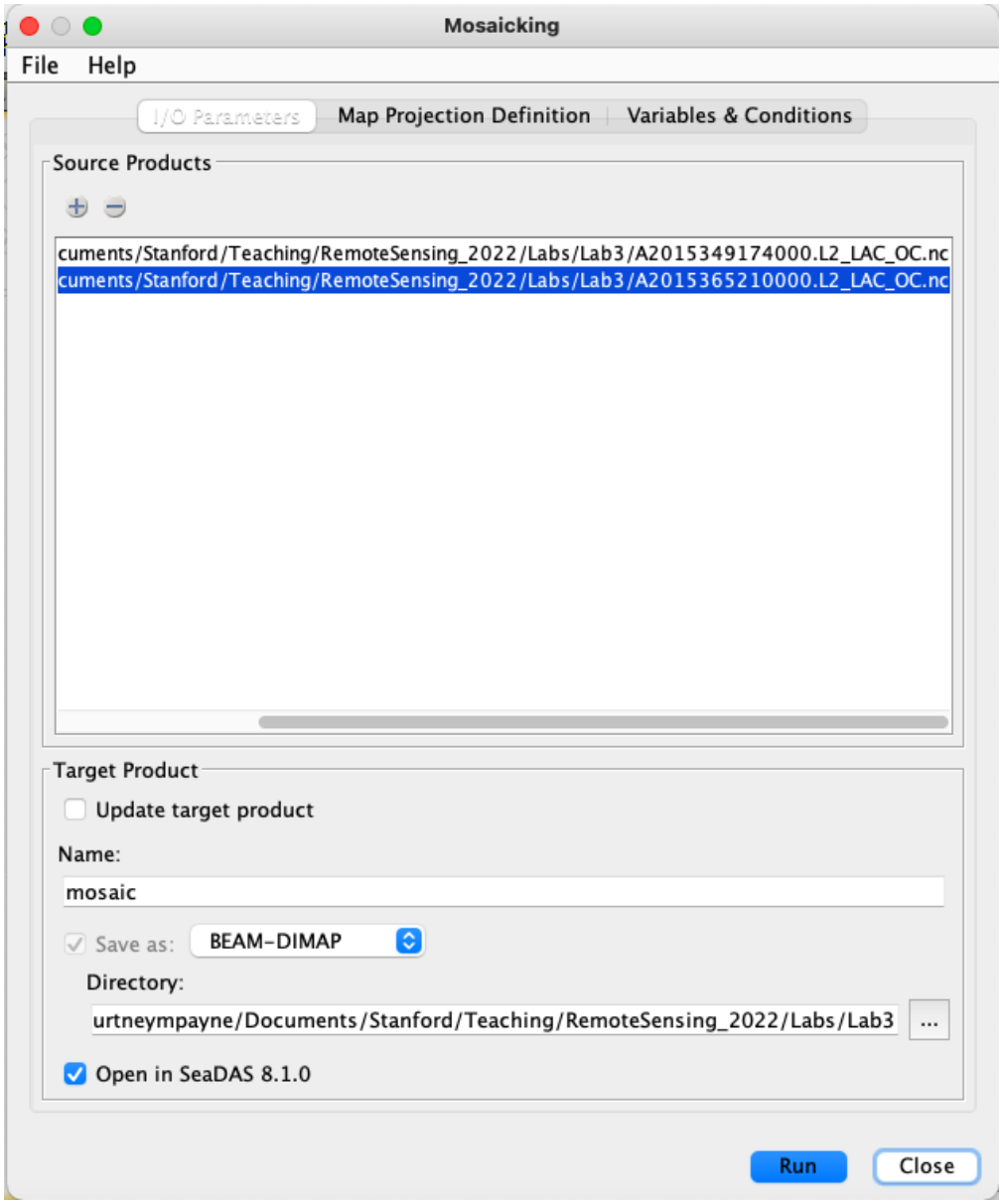


Now, after we project it, the scene is mapped onto an evenly spaced grid and the landmass is recognizable as the east coast of the U.S. (note: we have also added a landmask, shown in gray)

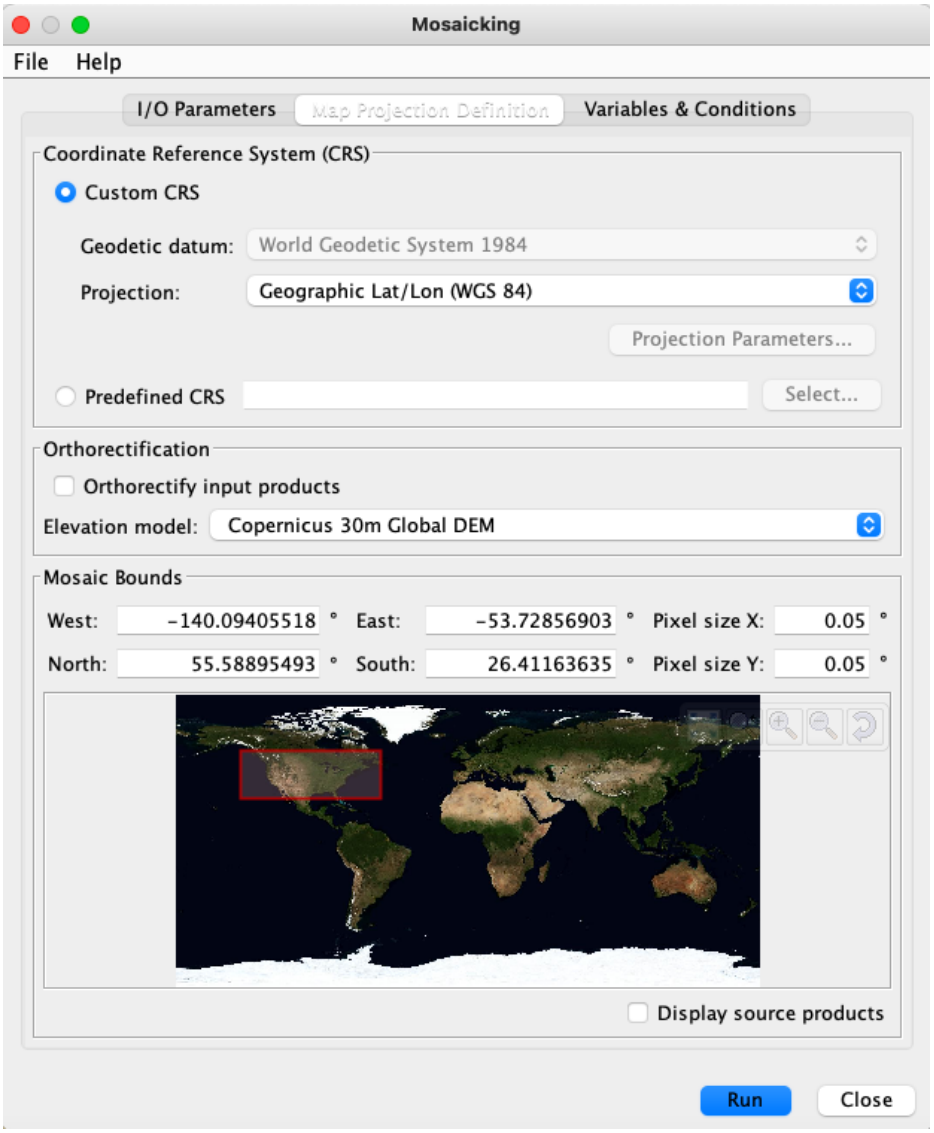


1. Now it's your turn to project an image!
2. Open one of the L2 MODIS oceancolor (unprojected) images that you copied from the Lab 2 folder
    a. Display a band and gridlines on it to see what the unprojected image looks like.
    b. Go to Raster > Geometric > Reprojection
        i. Under "Reprojection Parameters", you can:
            1. Select your projection and any other parameters. For now, you can leave the default reprojection parameters.
            2. Click run. This may take a few minutes.
            3. When it is finished, close the Reprojection window
        ii. Display a reprojected band and add and gridlines.
            1. You may add a landmask at this point, but this might slow you down as the mask loads.
            2. Notice the difference? Is the area more recognizable?
            3. Remember, if you are unsure of where your image is from, you can check the "World Map" window in the upper left to see where your scene is from. The active window will be displayed by the red box.
3. Now, repeat the reprojection process for the second L2 image.
4. The "Mosaic" tool allows for more flexible settings when projecting images. There are a few different uses for Mosaic:
    a. For example, "reprojecting" will project only within the lat/lon bounds of your scene whereas Mosaic allows you to choose the boundaries of your projection. With Mosaic you can project different scenes in exactly the same way whereas with Reproject the boundaries will depend on the lon/lat bounds of the scenes.

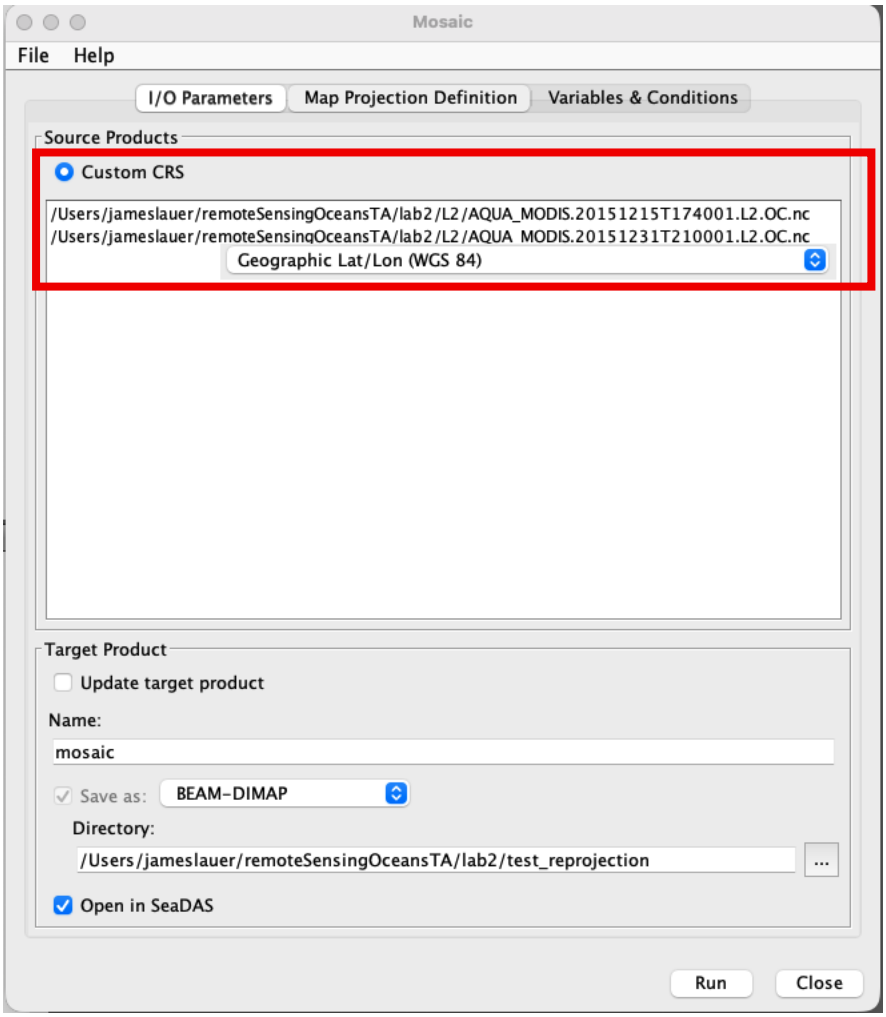
b. You can also create ‘Mosaic’ images with multiple L2 scenes on a single mapped image.
c. To make a Mosaic:
    i. Click Raster > Geometric > Mosaic
    ii. Under “I/O Parameters”
        1. Click “+” to add both of the L2 files you have been working with so far today
        2. Choose a name for the Mosaic output (default is ‘mosaic’)
        3. Change the directory (where your mosaic will be saved) if needed



d. Next, click “Map Projection Definition”
   i. **NOTE:** There is a bug in the current version of SeaDAS, and this screen will not load correctly. The screen should look like this, but because of an issue with the world map graphic, **this page will not appear. It will instead look like clicking “Map Projection Definition” did nothing**

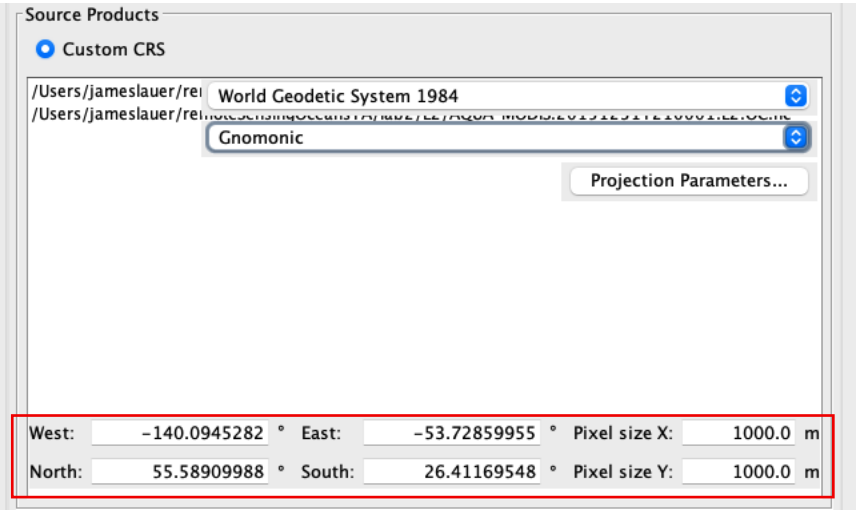


   ii. **TO WORK AROUND THE ISSUE:** Once you click on “Map Projection Definition”, hit the ‘tab’ key on your keyboard. This will cause ‘Custom CRS’ and a projection dropdown to appear on top of the previous menu. It should look like this:

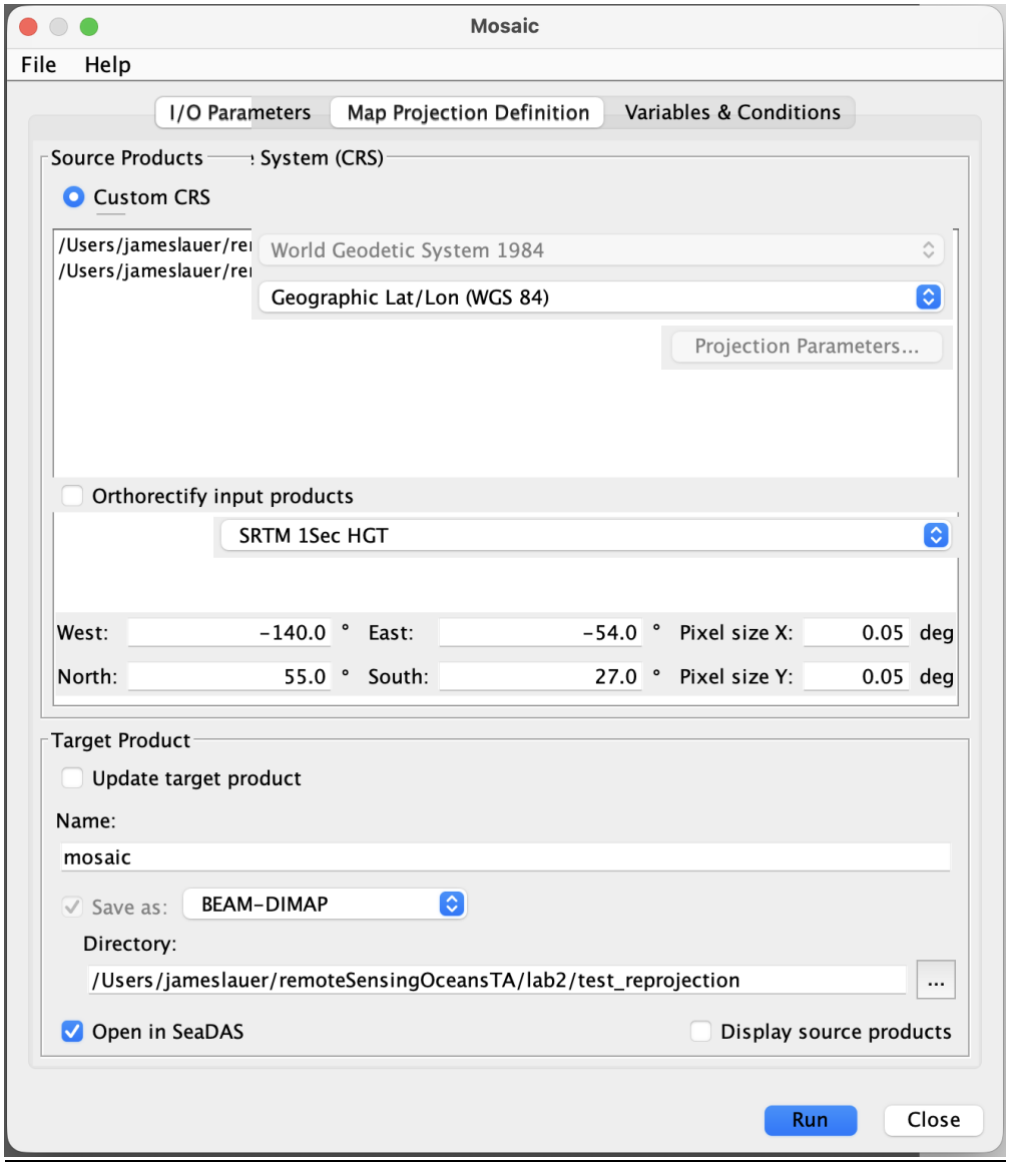


iii. Change the projection in the dropdown to any other projection (I used 'Gnomonic') you should see additional options appear in the middle of the menu – specifically lat/lon boundaries for your mosaic

iv.



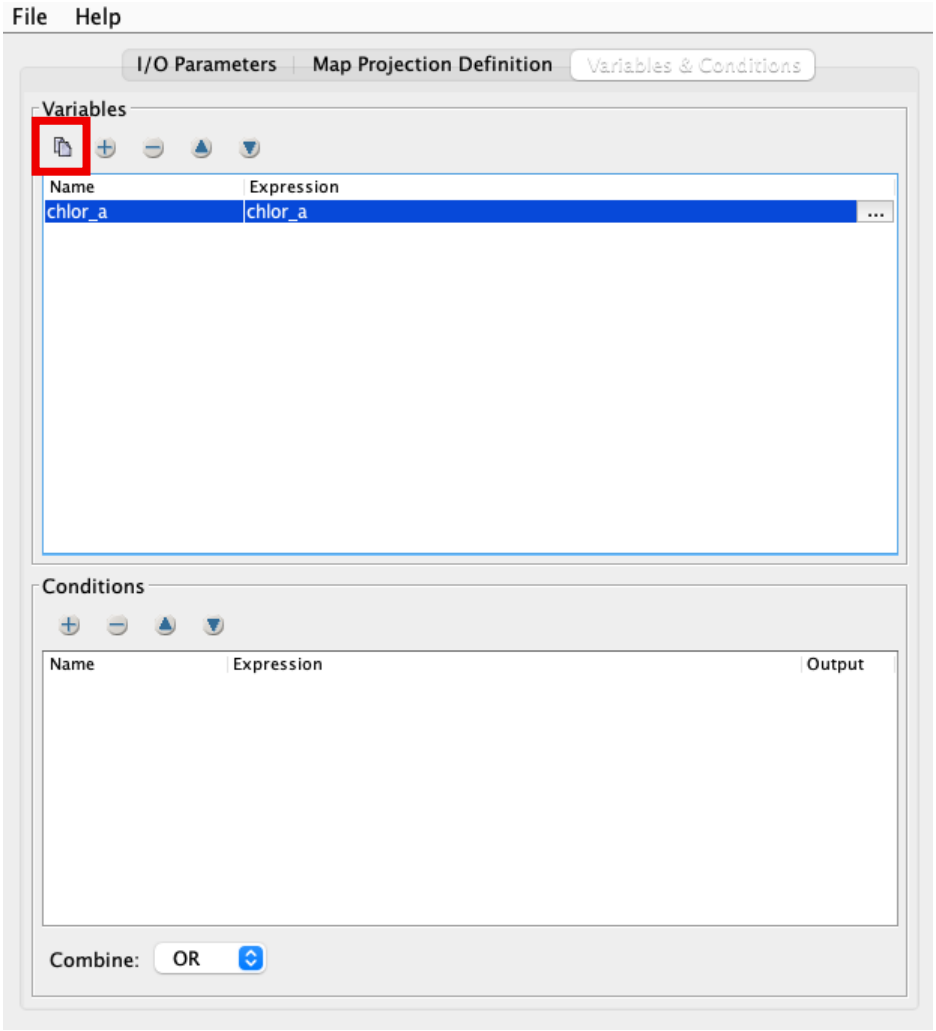
v. You can now freely change your map projection and modify the boundaries of your mosaic using the North, South, East, and West boxes
    1. The default projection is “Geographic Lat/Lon (WGS 84)”
    2. You can experiment with the different projections.



vi. To set the boundaries of your mosaic, it is helpful to overlay gridlines over the original images, and figure out the eastern, western, northern, and southern bounds from your gridlines

vii. **If you have any trouble with this step, call over one of the instructors!**

e. Once you are satisfied with your projection and boundaries, click over to "Variables & Conditions"
    i. Select  to pick which products (bands) to display
        1. There will be many options, chlor_a is chlorophyll a, and is the primary band we want to display today, but you can select all to preserve all bands.



    ii. Click "Run" to produce your mosaic
    iii. When it is finished running, close the Mosaic window
    iv. Display the new mosaic image
        1. Try adding a landmask and gridlines!

Before continuing to the next part of the lab save your SeaDAS session as a precaution, in case SeaDAS becomes unresponsive.

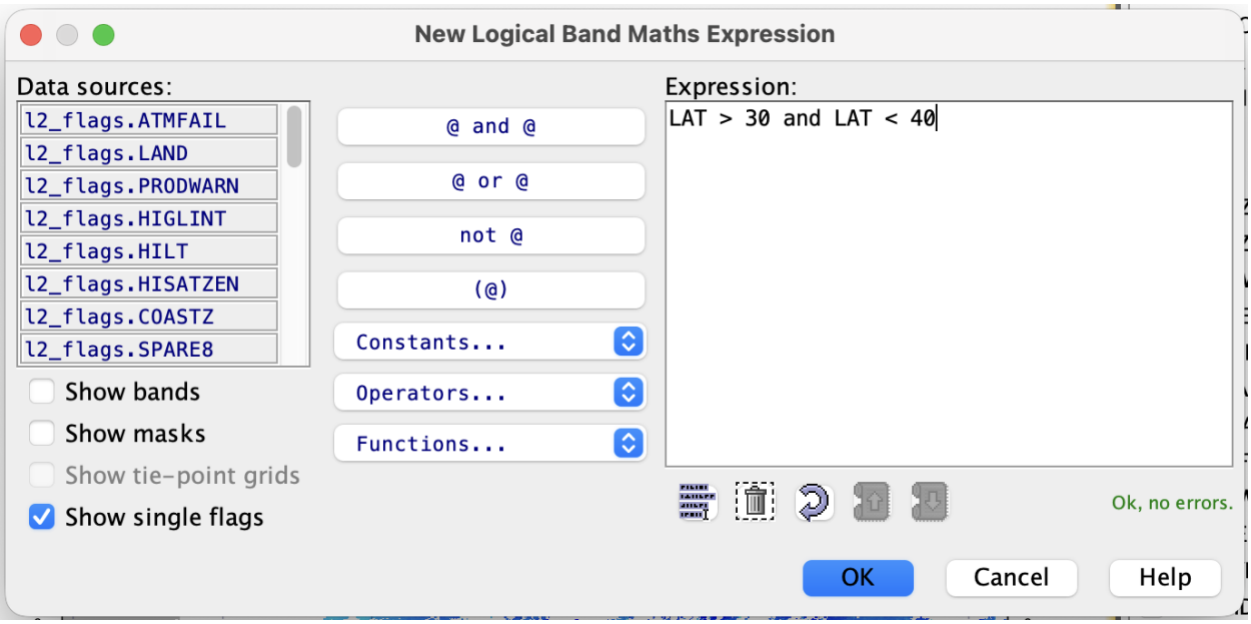
PART II DATA ANALYSIS: MASKS AND DATA EXTRACTION

Now that your image is projected, it's time to analyze the data! There are different approaches to data analysis of satellite images. You can either analyze the entire scene, but likely you'll want to analyze a consistent region of interest (ROI). You can do this by creating a "mask":

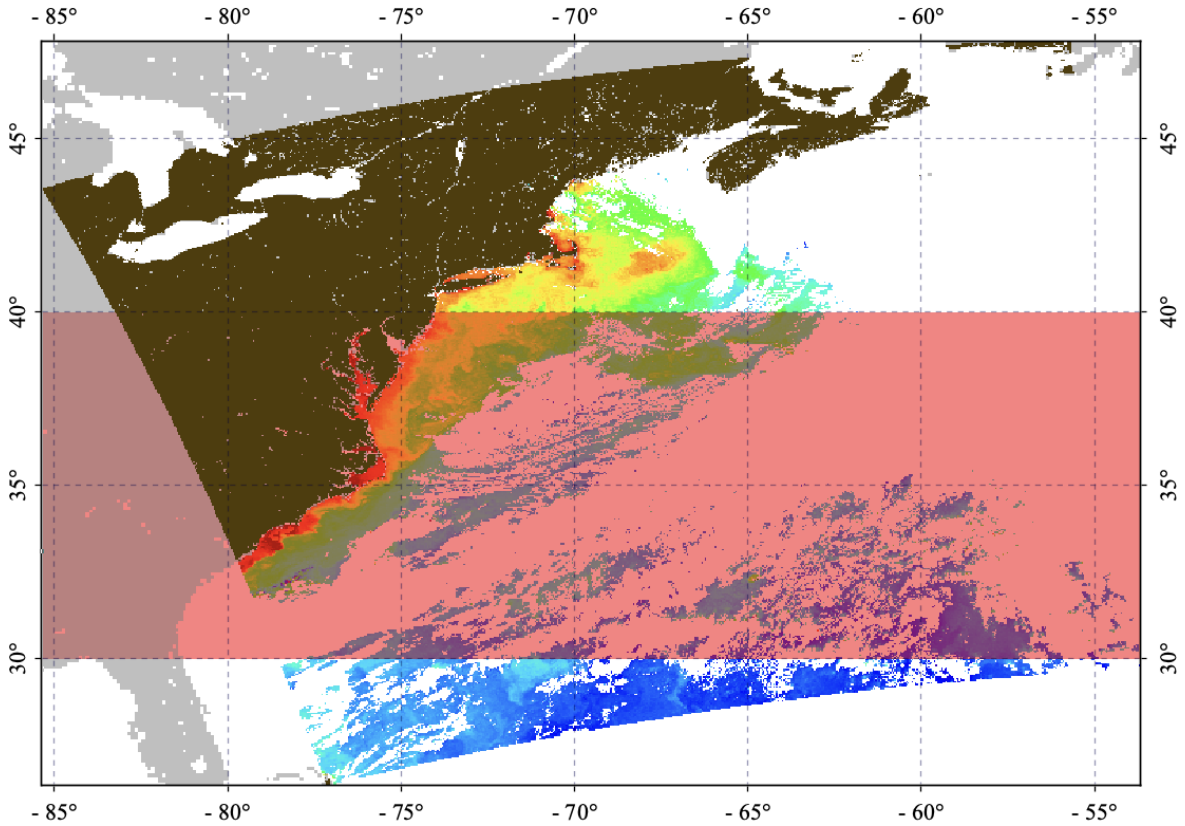
MASKS:

1. Now, display the projected L2 image (not the mosaic) of the East Coast of the USA

2. You can create a mask to analyze data constrained to a certain region. Any mask you create (like the land masks you made previously) are stored in the "Mask Manager" (window on the right). Go there now:
    a. Logical Band Maths Expression: f(x)
        i. Before you open the Band Maths Expression window, first get an idea of where you want to put your mask.
            1. Look at the "Pixel Info" window on the right while you move your cursor to get a sense of the lat/lon of your image.
            2. Write down the lat/lon limits you want for the mask you will create next.
            3. Remember that West and South are negative.
        ii. Now, open the Logical Band Maths Expression by navigating to the Mask Manager and then clicking f(x) where you can use different criteria in your math expression. **Make sure to use the logical band maths expression button in the mask manager panel (not in the top panel).**
        iii. You can use any variable listed under Data sources. For this example, let's constrain by latitude and longitude. In that case, these will be your "constants".
            1. Note: if you use the latitude or longitude BANDS from your image, the mask will only extend to the boundary of your image. LAT and LON can also be found in the "Constants" dropdown, and this will create masks that can extend beyond a single image.
        iv. You can create a math expression to constrain your mask. You can create the expression using the buttons or by typing. You can check whether you've typed it accurately by the text at the bottom ("OK, no errors")



v. Click “OK”
vi. Now, your mask should be displayed on your scene (see below)



vii. If your mask isn't displaying where you expected, you likely made a mistake in writing the band math expression. If you want to edit the expression, select the mask you just made in the mask manager list and click the edit icon 

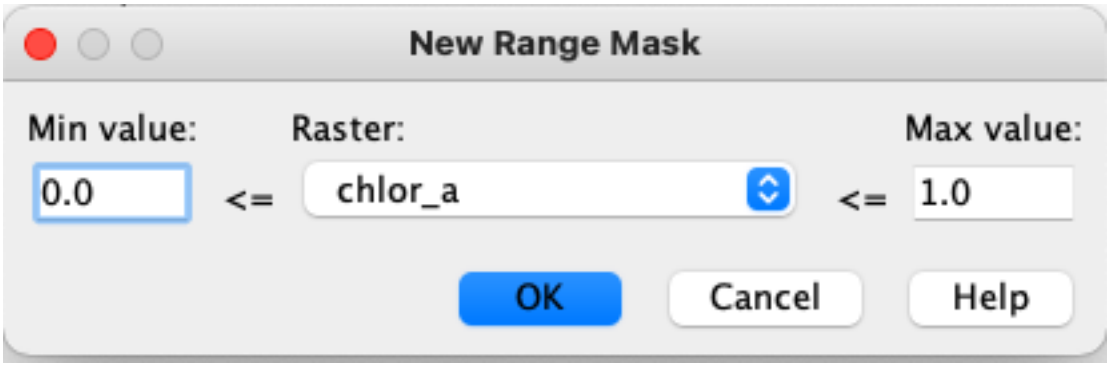
viii. Under "Mask Manager", you can toggle the mask on/off and change the color/transparency of the mask

ix. In Mask Manager, when a mask is selected, you can:

1. Edit the mask criteria 
    a. Hint: you must edit in the "editor" window. You cannot edit by changing the text description box to the right of the color/opacity. That is only the *description,* not the mask criteria!
2. Double click to change the mask name (this is helpful when you start making many masks!)
3. Change the color and transparency

x. You can also create masks based on value range using the Range Mask ()

1. This way of creating a mask is based on your data (and this can be based on data from another band that you're not currently displaying!)
2. For instance, you can create a layer that masks where chlor_a is between 0 and 1

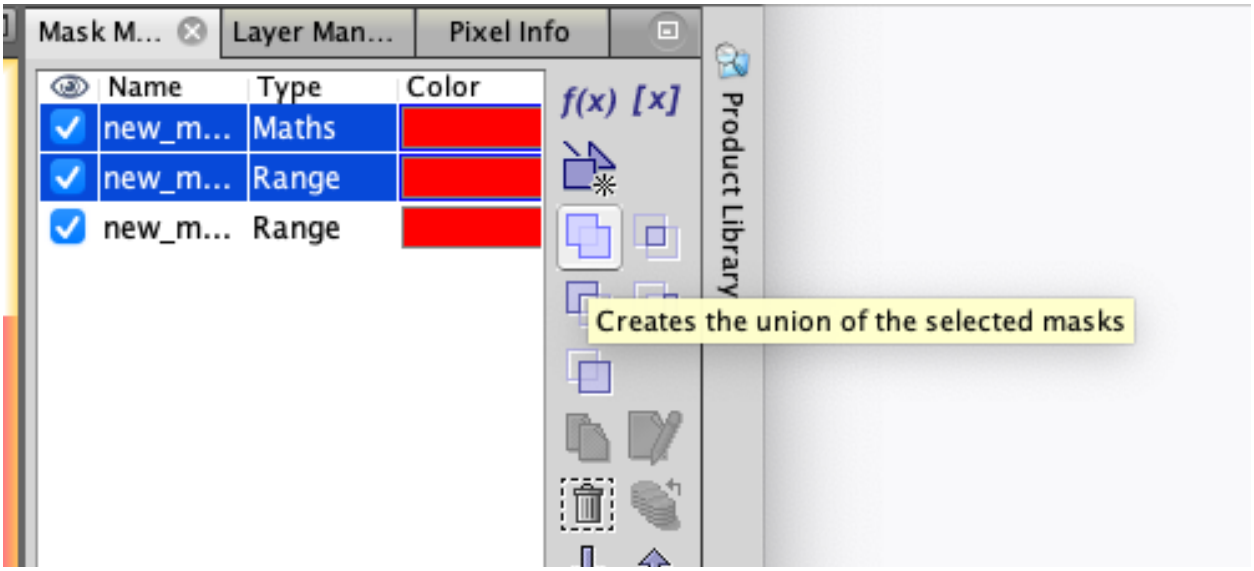


xi. There are pre-made masks that are included with your L2 images.

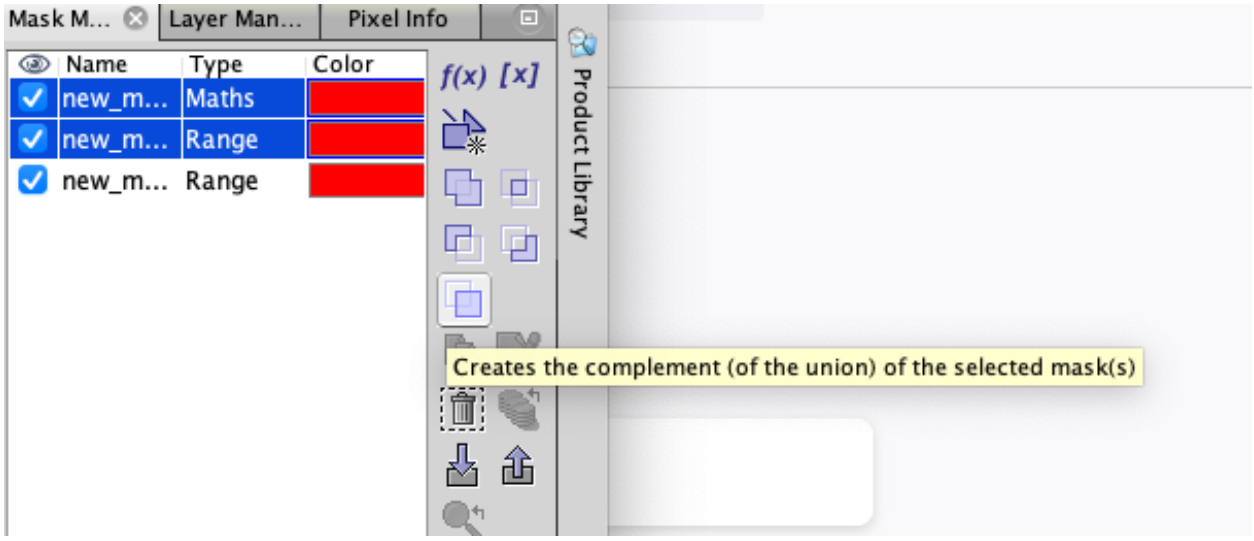
1. For example, some of these masks are for pixels that are "flagged" for a variety of quality control reasons.
2. Hover over the different pre-made masks to read the descriptions
3. If you wanted to create a mask that encompassed multiple masks for "bad" data so you can exclude it for your analysis, it might make sense for you to create a mask that

encompasses all these flagged pixels

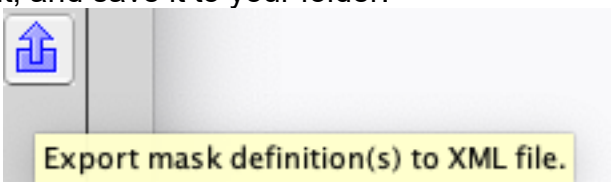
4. To do so, highlight the masks you want to include (by holding the command key) and click the button to “Create a union of selected masks”



5. This creates a new mask, perhaps called “not_valid”
6. If you wanted to create the complement mask of “not_valid” (aka, VALID data pixels), highlight “not_valid” mask and click 

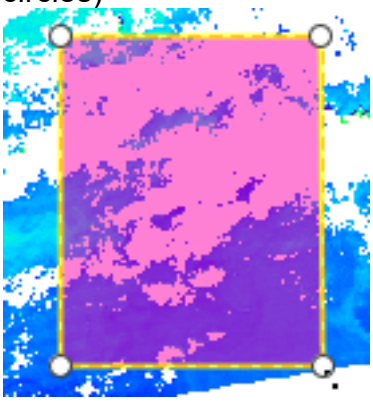


xii. Often times in data analysis, you may want to save your mask to use repeatedly.
   1. You can do this for individual masks or a group of masks. Highlight the masks you want to include (to select multiple at once by holding down the command key)

2. Export the mask by pressing the “export” icon (see below), name it, and save it to your folder.
   a. 

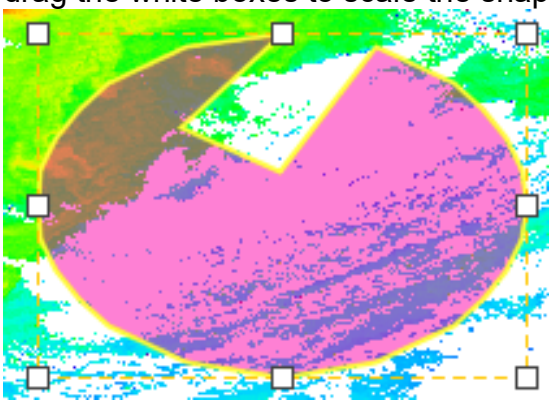
3. Now, delete that mask just exported from mask manager.
4. Try reimporting the mask and displaying it on your OC image

xiii. Finally, you can create “Geometry” masks. These are slightly different from the previous masks because they are vector data (vs. raster data). If you want to know more about the difference between vector and raster data, you can see the SeaDAS Help Page
   1. You can create a new square, circular, or polygon shape 
      a. For polygons, click to add a new vector point. When you are finished, double click to close the shape
   2. To edit the geometry shapes, use the pointer tool
      a. Select a single geometry by clicking it.
      b. Select one or more geometries by dragging a selection rectangle around them.
      c. Double click the shape to enable the vector points (white circles)



      i. **Move the shape:** Selected shapes can be moved to another location by clicking and dragging them with the mouse when it is in mouse mode.
      ii. **Move a vector point:** Click and hold a vector point to move a single vector point.
      iii. **Add a vector point:** Click and hold a vector point. Then hold control and move the new vector point.

iv. **Remove vector points:** Click and hold the vector point you want to remove. Move the point on top of another vector point, then hold control, then release the key and the mouse.
v. **Scale:** Click the shape again so that the entire shape is surrounded by the square box with white square points. You can click and drag the white boxes to scale the shape.



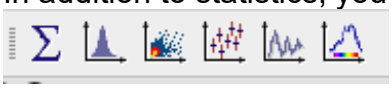
vi. **Cut, Copy, Paste:** Click to select the shape. In the **Edit** menu, cut or copy. Then Edit>paste.
vii. **Delete:** Use the command from the **Edit** menu or use the **Delete** key.

3. You can save the shape two ways:
    a. One, as a shapefile:
        i. Right-click on 'geometry' (or geometry_1, … if you made more than one) in the "Vector Data" folder of your file in **File Manager**.
            1. NOTE: NOT Layer Manager
        ii. Select "Geometry as Shapefile"
        iii. Test it on another file before closing the image. (Vector -> Import -> ERSI Shapefile)
    b. Two, as text:
        i. Selecting the geometry shape you want to save
        ii. Right clicking the shape and selecting "WKT from Geometry"
        iii. Copy (command + C) the text (which includes the lat/lon of all the vector points)
        iv. Then, to add the shape file, right click the image and click "Geometry from WKT" and paste in the text.
        v. The shape should be added.
        vi. If you want to use a mask repeatedly during your analysis, you could save this text to use in future SeaDAS sessions.

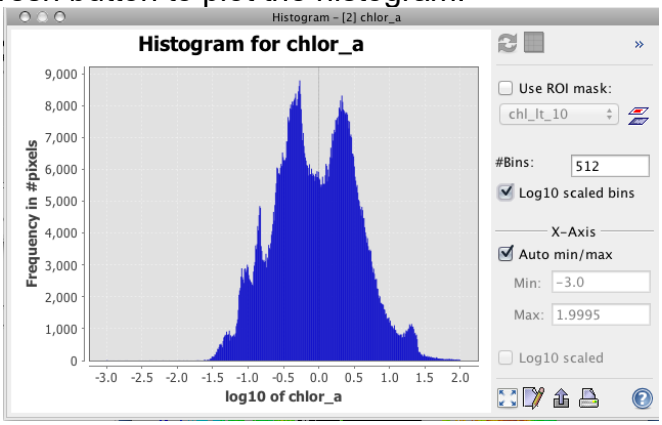
STATISTICS + PLOTS:

2. To analyze your image or data within a mask, you can do some statistics by clicking the statistics button (Σ) or Analysis > Statistics
    a. First, make sure the band you want to analyze is selected in "File Manager" (for example, the "chlor_a" band)
    b. You can select one of your regions of interest (ROI) as a mask or leave it blank to analyze the entire image
    c. Click the "Run" to analyze
    d. You can export the data to a spreadsheet by highlighting it and just copying and pasting.

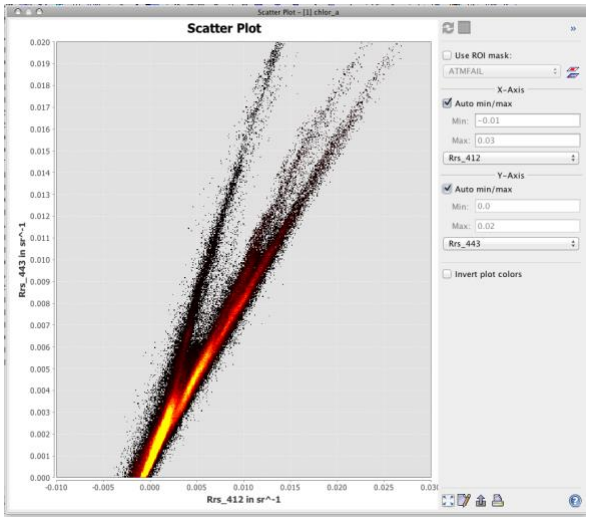
3. In addition to statistics, you can visually display your data with a variety of plots



    a. You can find these same options under the Analysis menu
    b. First, make sure the band you want to analyze is selected in "File Manager" (for example, the "chlor_a" band)
    c.  You can create a histogram which tells you about the distribution of your data. For something like chlorophyll, a log scale may be most appropriate. Once you have selected the scale and axes you'd like, click the refresh button to plot the histogram.



    d.  You can create a scatter plot that shows the relationship between two parameters (for instance, two different bands or data vs. latitude). Once you have selected the scale and axes you'd like, click the refresh button to plot the histogram.



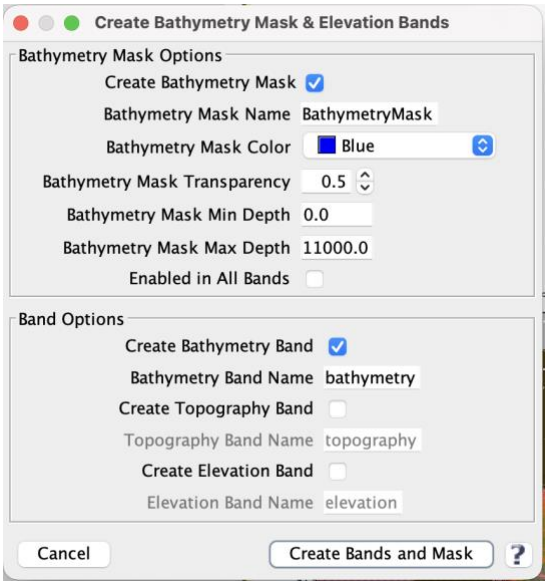
e. To save either histogram or scatter plots as a picture (png file), right click on the image, then click Save As > PNG

BATHYMETRY:

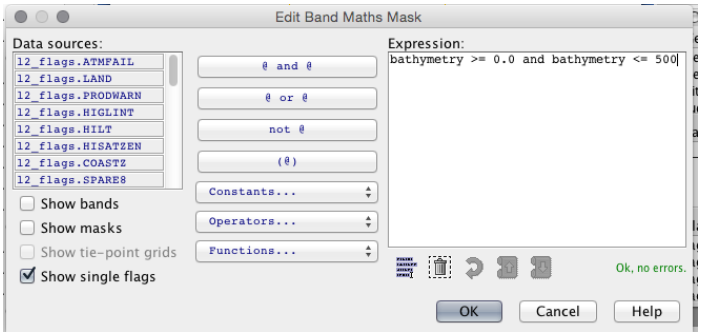
4. You can also look at the <u>bathymetry and elevation</u>

a. Click  . Leave the parameters as is, and click "Create Bands and Mask." When you use this tool for the first time you will be prompted to download the bathymetry database first.

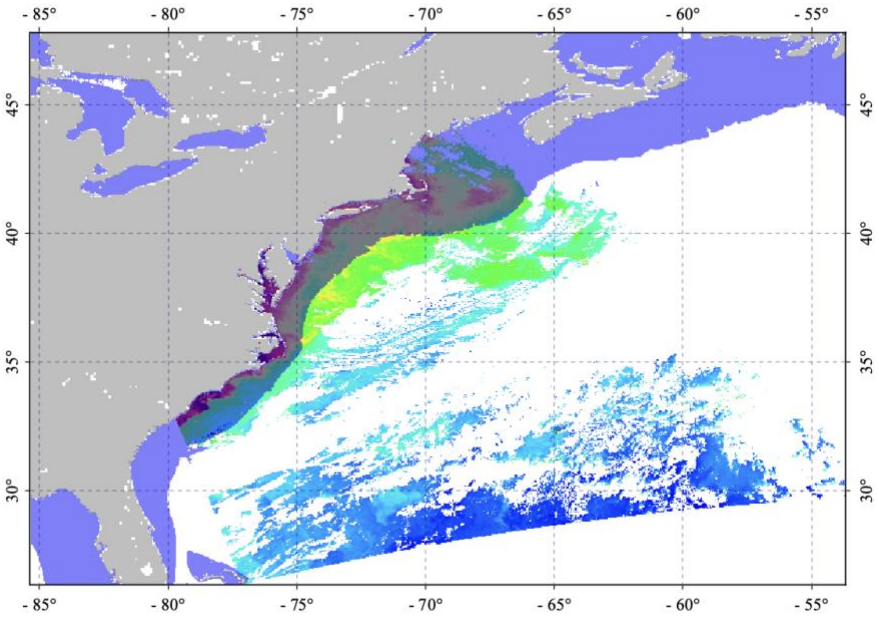
i. You can create topography and elevation bands alongside bathymetry by clicking the check boxes under Band Options



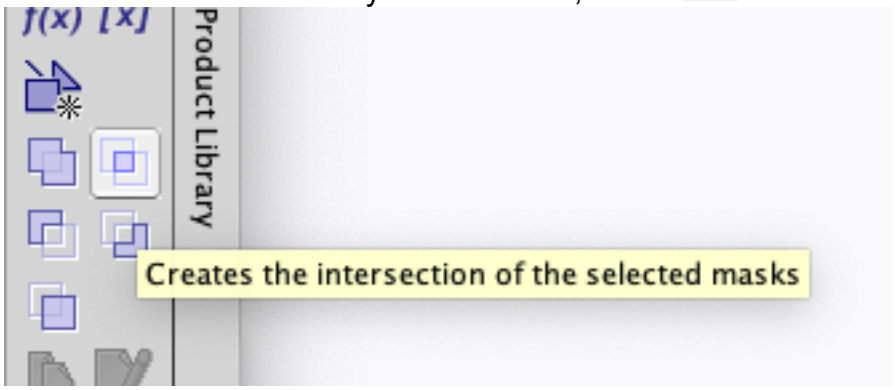
b. You have created up to three new bands: bathymetry, topography and elevation. From File Manager, display the bands you created and use the cursor to get a sense of these values.
c. This also creates the mask “BATHYMETRY” in mask manager
    i. If you wanted to visualize where on your map the bathymetry is less than a given depth, open the mask editor for the bathymetry mask. Here’s how you would change it for if you wanted to see where on your map the bathymetry was shallower than 500m using Band Maths.



    ii. You could also do the same thing (limiting the bathymetry to shallower than 500m) by using the Range Mask ([x]). Try it!
    iii. Now the new bathymetry mask indicates that the blue masked area has a bottom depth shallower than 500m



d. Now, let's try creating a new mask that only contains chlorophyll where the depth is greater than 500m
   i. Select the Chl a mask and the bathymetry mask (by clicking one, holding "command" and clicking the other).
   ii. To make a mask that obeys both criteria, select 



1. Try using the different options including creating masks that are a union, difference or complement of the selected masks.
2. Another way to create this mask is to edit the Band Maths Mask expression as: bathymetry > 0 and bathymetry < 500 and chlor_a > 0

DATA EXTRACTION:

1. To extract data from your satellite image, you can: Right click on the image to "Export Mask Pixels" and select a mask. This will generate a text file with data from all the bands from all the pixels within your mask ROI. Beware, this can be a very big file if you do a large mask!
2. You can also use the Pin tool and Pin manager to extract data from specific coordinates

At this point, SAVE YOUR SESSION! You may want to revisit this session in LAB 3

Getting Credit for this Lab:

To get credit for this lab we want you to create a histogram of Chlorophyll *a* data from inside the mask you just created (Bathymetry > 500m). Save the histogram as a PNG file and email it to Prof. Arrigo (arrigo@stanford.edu).

If you have any questions, do not hesitate to ask!