National Aeronautics and Space Administration

Advanced Skills with SeaDAS

Integrating Remote Sensing into a Water Quality Program

June 5-19, 2019

Objectives & Learning Outcomes

- In this section you will learn:
  - Collocate Bands
  - Band Math (Math Band)
  - Statistics
  - Filter Band
  - Pixel Extraction
  - Combine (Mosaic) Two Images

Beginning Steps

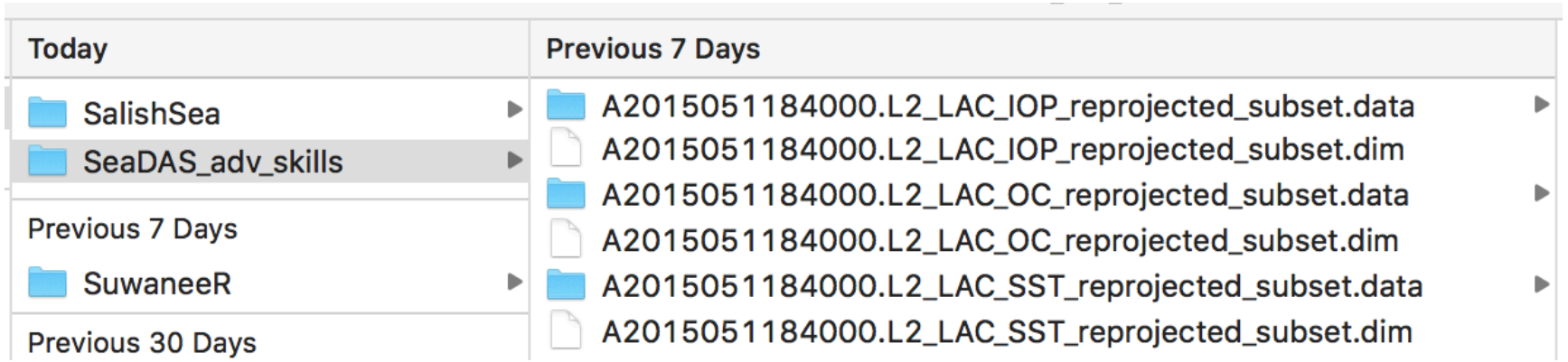
1. Open SeaDAS
2. Navigate to the Part 1 exercise folder you created in the first week
3. Recall that you reprojected and cropped a subset of data from the original L2 files for OC, SST, and IOP. The names of the files are as follows:
   - A2015051184000.L2_LAC_OC_reprojected_subset.dim (and supporting .data file)
   - A2015051184000.L2_LAC_SST_reprojected_subset.dim (and supporting .data file)
   - A2015051184000.L2_LAC_IOP_reprojected_subset.dim (and supporting .data file)

Important Note

- These reprojected_subset image files all need to be cropped with the same geographic coordinates
- If your reprojected_subset images are not cropped along the same geographic coordinates across all files, then the following collocate bands steps will fail
- If you need to repeat the cropping step in Exercise 1, do so now
- For the Part 1 exercise, we used the following geographic coordinates North = 30.485, South = 25.986, West = -84.551, East = -81.739
- **You don’t have to use those coordinates, just be consistent across all of the files**

Beginning Steps

4. Create a new folder named **SeaDAS_adv_skills** and copy the .dim and .data files for these reprojected subset files into that new folder



Collocate Bands

Collocate Bands

Band Math

Statistics

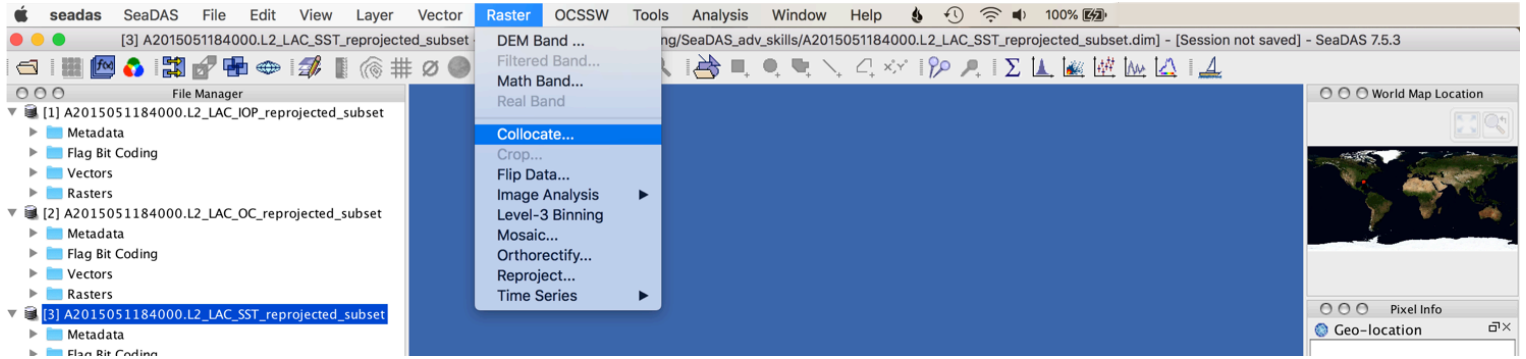
Filter Band

Pixel Extraction

Combine (Mosaic) Two Images

- When you wish to combine bands from different files for a given scene, use the collocate tool. In this example, we are combining the SST, IOP, and OC data.

1. From the **SeaDAS_adv_skills** folder, open:
   - A2015051184000.L2_LAC_OC_reprojected_subset.dim
   - A2015051184000.L2_LAC_SST_reprojected_subset.dim
   - A2015051184000.L2_LAC_IOP_reprojected_subset.dim
2. In SeaDAS, at the menu bar, click on **Raster** > **Collocate**



Collocate Bands

Collocate Bands

Band Math

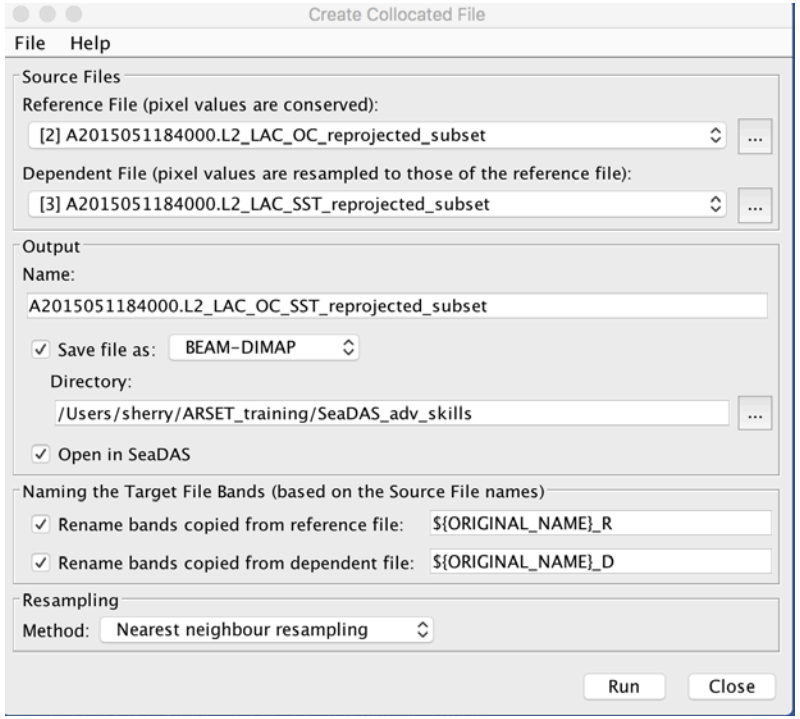
Statistics

Filter Band

Pixel Extraction

Combine (Mosaic) Two Images

3. This will open a window. Select the OC file as the Reference File and the SST file as the Dependent File.
4. Confirm that your entries for Reference File, Dependent File, and Output Name match what you see in the image to the right.
5. Click **Run** and wait a moment



Collocate Bands

Collocate Bands

Band Math

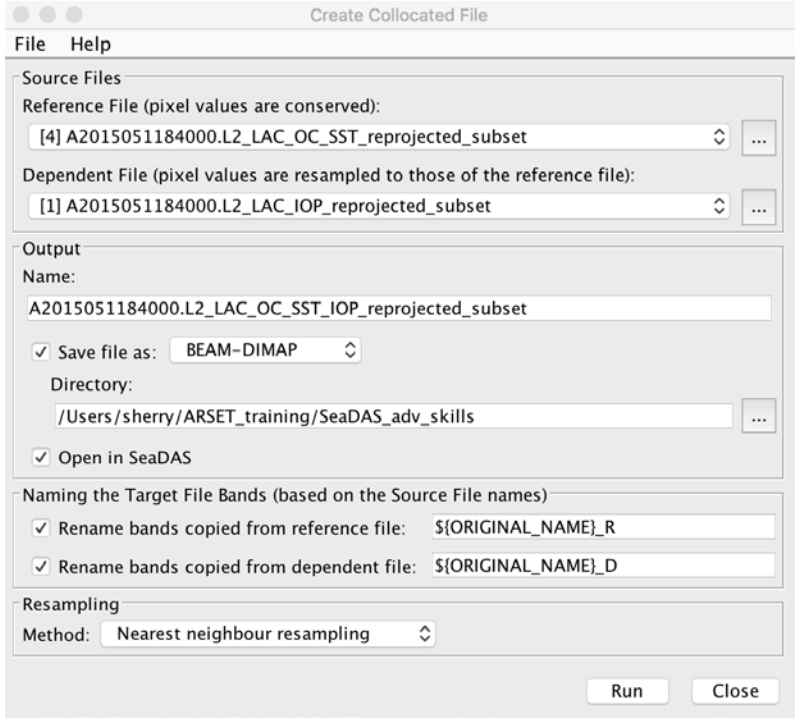
Statistics

Filter Band

Pixel Extraction

Combine (Mosaic) Two Images

6. Repeat the collocate step using this newly collocated file as the Reference File and the IOP file as the Dependent File.
7. Confirm that your entries for Reference File, Dependent File, and Output Name match what you see in the image to the right.
8. Click **Run** and wait a moment



Collocate Bands

Collocate Bands

Band Math

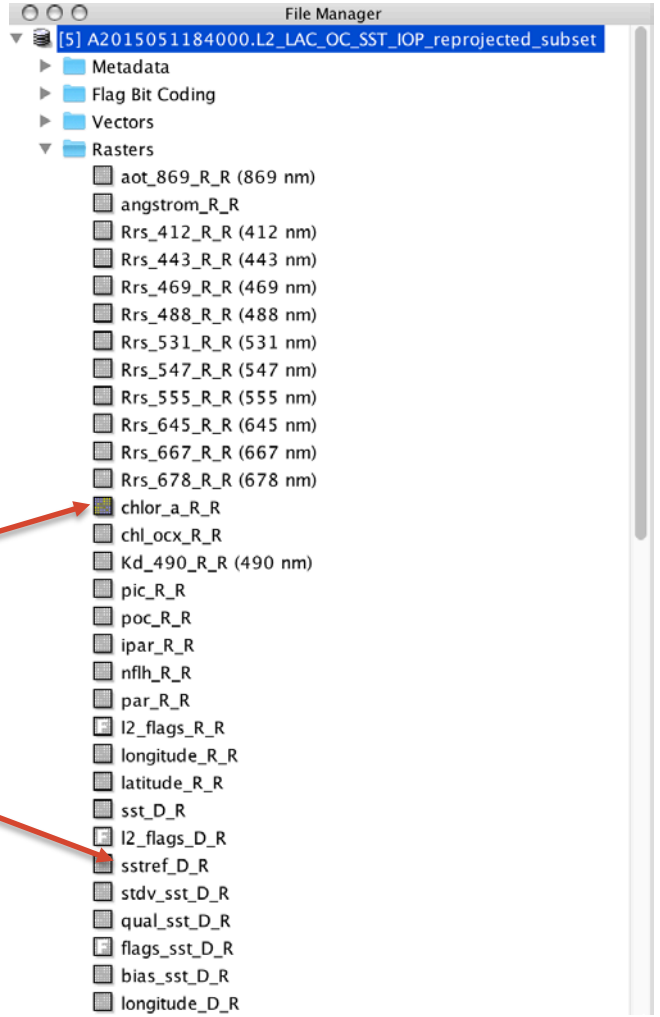
Statistics

Filter Band

Pixel Extraction

Combine (Mosaic) Two Images

9. When processing is complete, close all files except the newest file: A2015051184000.L2_LAC_OC_SST_IOP_reprojected_subset.dim
10. Click on the **Rasters** folder in the **File Manager**
    - Note the bands from both files are now in this one
    - Data products from the reference file are appended with “R” and the dependent file are appended with “D”
11. View the chlor_a_R_R band
12. Try opening other bands and exploring this region on the West Florida Shelf and Suwannee River Mouth



Collocate Bands

Collocate Bands

Band Math

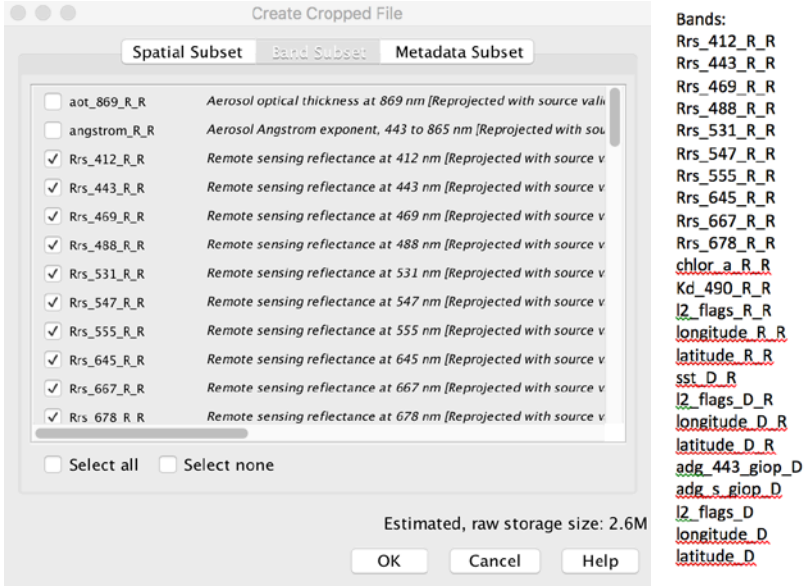
Statistics

Filter Band

Pixel Extraction

Combine (Mosaic) Two Images

13. If you prefer to reduce the number of bands in this file, you can use the **Raster** > **Crop...** tool
14. Select **Band Subset** instead of **Spatial Subset**, as used earlier
15. Use the **Crop** > **Band Subset** tool to create a new file that includes the following bands



16. This will create a new file that will be visible in the **File Manager** pane to the right. Be sure to right click on the file and save it with a new name: A2015051184000.L2_LAC_combined.dim
17. Close all of the other files and explore this one by opening the chlorophyll, SST, and adg_443_giop data layers
18. Close all of the image layers in the viewing window

Band Math (Math Bands)

Collocate Bands

Band Math

Statistics

Filter Band

Pixel Extraction

Combine (Mosaic) Two Images

- Sometimes it is useful to gain insight from imagery by performing math on the bands
- NASA uses a number of chlorophyll algorithms because conditions vary regionally and different algorithms are tuned for different regions
- The data product we've been focused on during these exercises is named chlor_a, but there are other algorithms
- A more detailed description of a number of algorithms, including chlor_a, can be found here:
  - https://oceancolor.gsfc.nasa.gov/atbd/chlor_a/

Band Math (Math Bands)

Collocate Bands

Band Math

Statistics

Filter Band

Pixel Extraction

Combine (Mosaic) Two Images

- For this band math section of the exercise, we will compute the Color Index (CI), which can be used as an intermediate step to compute chlorophyll
- The CI equation:

$$CI = R_{rs}(\lambda_{green}) - [R_{rs}(\lambda_{blue}) + (\lambda_{green} - \lambda_{blue})/(\lambda_{red} - \lambda_{blue}) * (R_{rs}(\lambda_{red}) - R_{rs}(\lambda_{blue}))]$$

- The R_{rs} wavelengths in the CI equation above map to the following MODIS band colors

"Color"	R_{rs} λ (nm)
Blue	443
Green	555
Red	667

Band Math (Math Bands)

Collocate Bands

Band Math

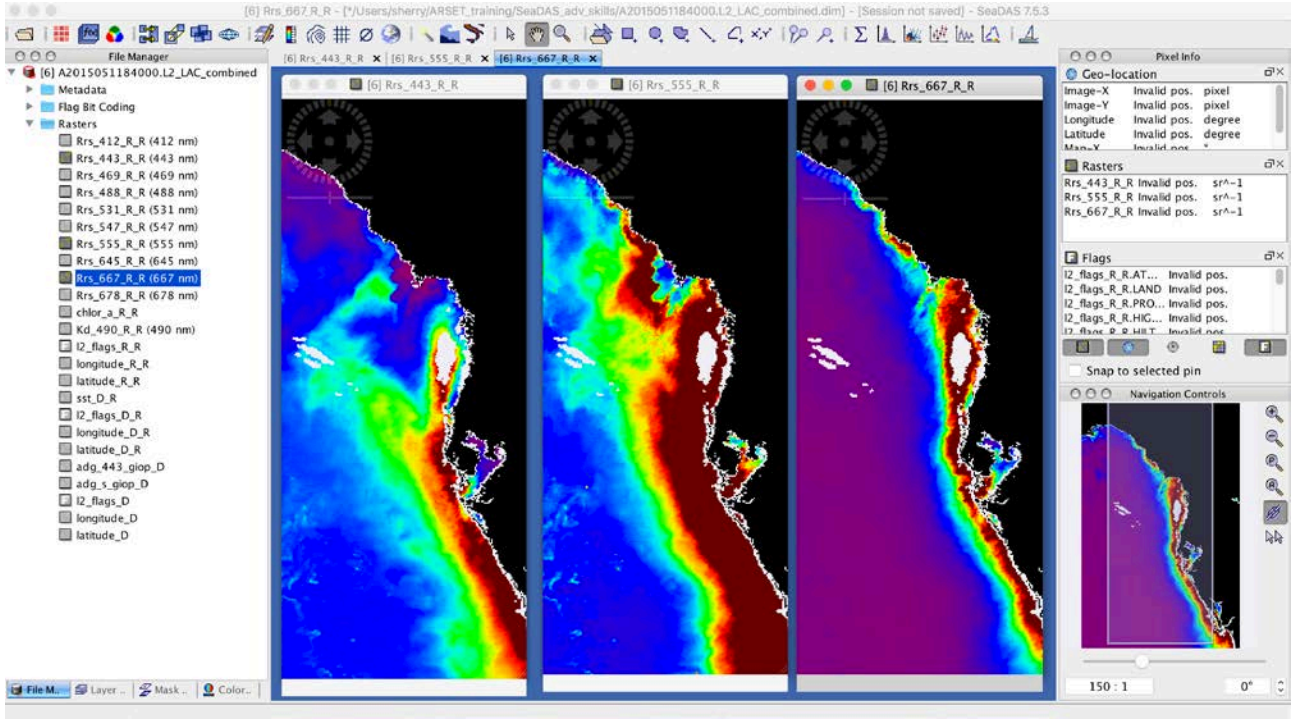
Statistics

Filter Band

Pixel Extraction

Combine (Mosaic) Two Images

1. In SeaDAS, double click on the R_{rs} image layers corresponding to the blue, green, and red bands in the CI algorithm
2. Apply land masks
3. Tile the images horizontally



Band Math (Math Bands)

Collocate Bands

Band Math

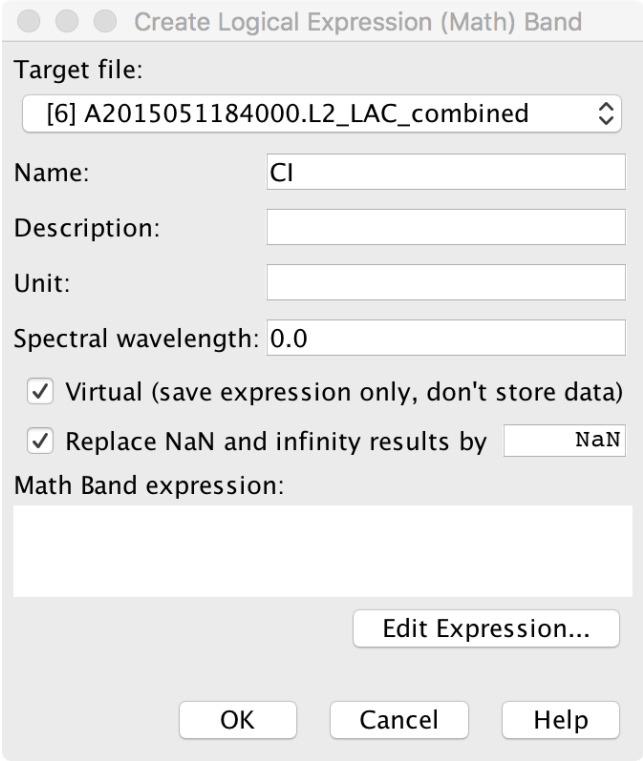
Statistics

Filter Band

Pixel Extraction

Combine (Mosaic) Two Images

4. Access the Math Band tool either from the menu bar, **Raster** > **Math Band**, or from the toolbar with the math band icon:
5. Click on it. It should show the combined file you just created.
6. Give the new band you are about to create the name: CI
7. Use the **Edit Expression** tool to enter the Math Band expression



Band Math (Math Bands)

Collocate Bands

Band Math

Statistics

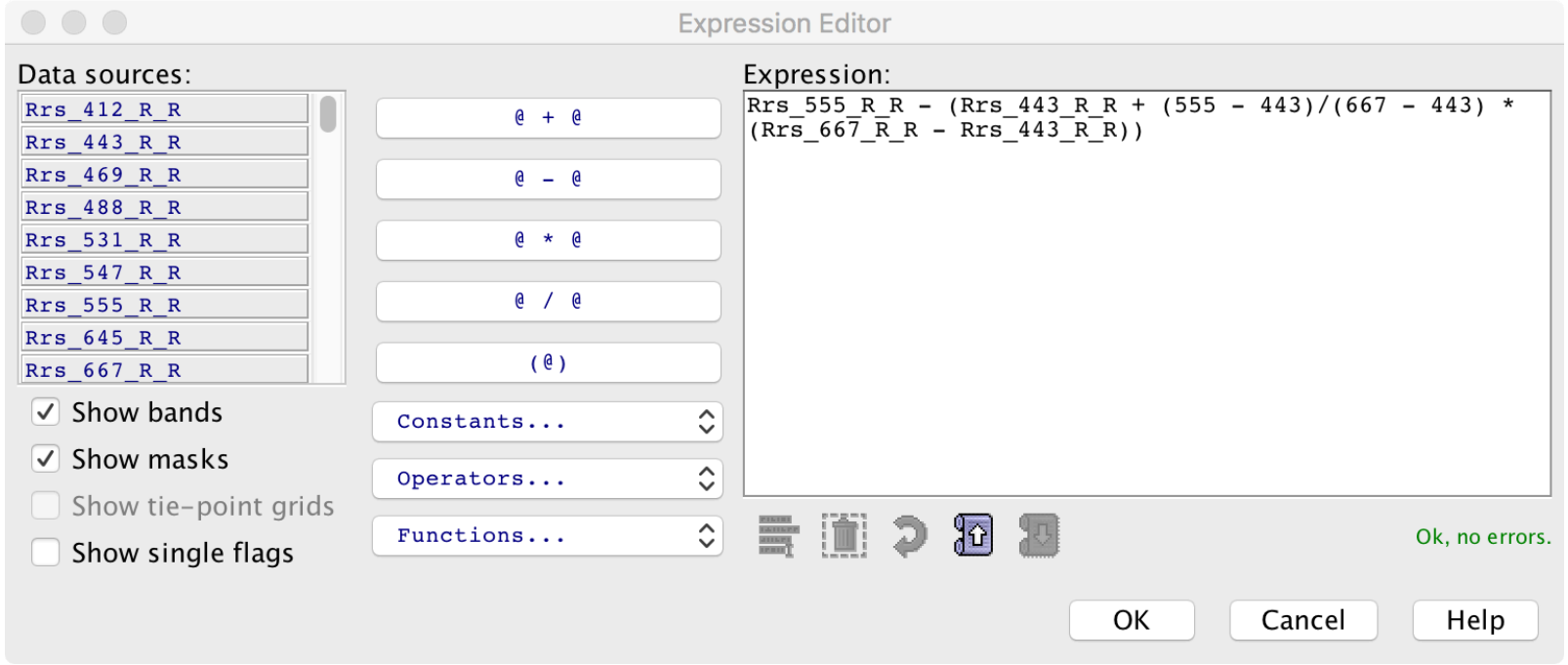
Filter Band

Pixel Extraction

Combine (Mosaic) Two Images

- We advise you use the expression editor for the math band instead of tying the equations out in the **Create Logical Expression (Math) Band** window.

8. Click **OK** to close the Expression Editor



Band Math (Math Bands)

Collocate Bands

Band Math

Statistics

Filter Band

Pixel Extraction

Combine (Mosaic) Two Images

9. Click **OK** in the **Create Logical Expression (Math) Band** window to begin the process
10. When the new band appears, it is a virtual band. In the **File Manager**, right click on this new CI band and select **Real Band**.
11. The band should appear in the viewer. Give it a land mask and adjust the color manager so that you can view variability in the CI over the West Florida Shelf
12. Right click on the file (A2015051184000.L2_LAC_combined.dim) and select **Save as...**
13. Save it by the same name, overwriting the original
14. Close all image layers

Statistics

Collocate Bands

Band Math

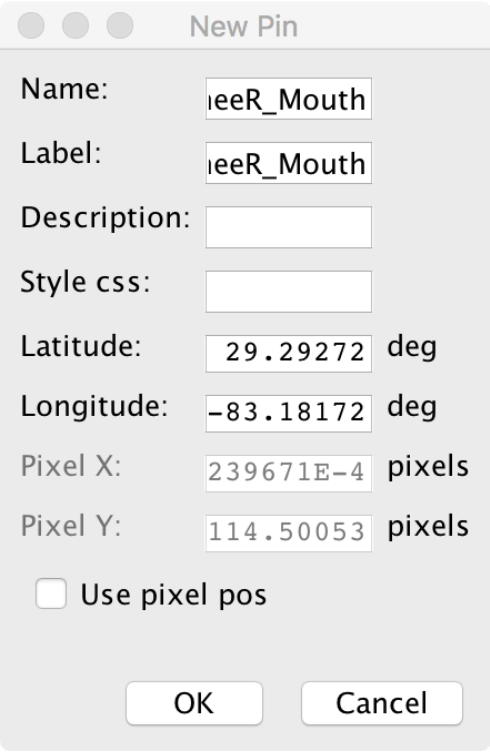
Statistics

Filter Band

Pixel Extraction

Combine (Mosaic) Two Images

1. Double click on the image layer named **sst_D_R**
2. Click on the pin manager
3. Click on the create and add new pin icon in the pin manager window
4. Name and label the new pin **SuwanneeR_Mouth** and give it the following decimal degrees latitude and longitude: 29.29272, -83.18172



Statistics

Collocate Bands

Band Math

Statistics

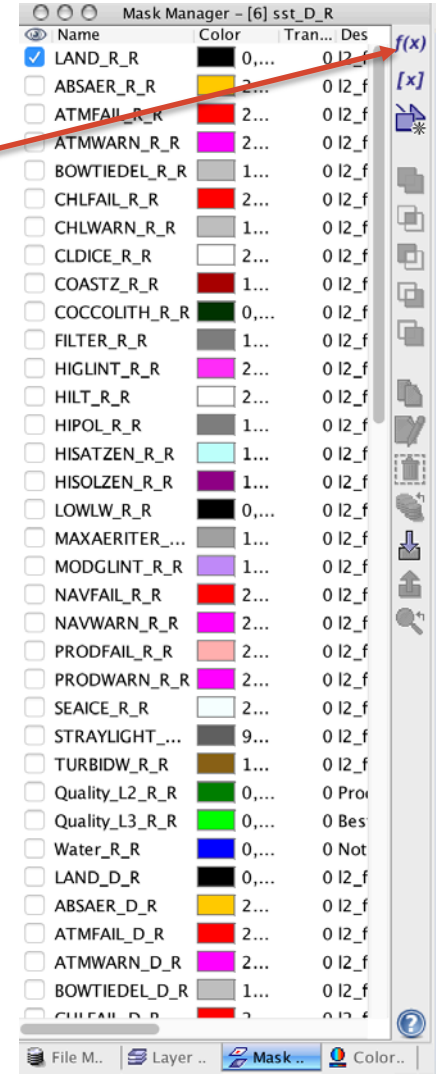
Filter Band

Pixel Extraction

Combine (Mosaic) Two Images

5. Navigate to the **Mask Manager** along the left pane of the viewer
6. Click on the **Expression Editor** function icon located within the **Mask Manager**

- We are going to create a mask that includes sea surface temperatures (SST) in the range of 9° C to 13° C
- **Note:** Do not confuse this function icon with the other function icon on the main tool bar



Statistics

Collocate Bands

Band Math

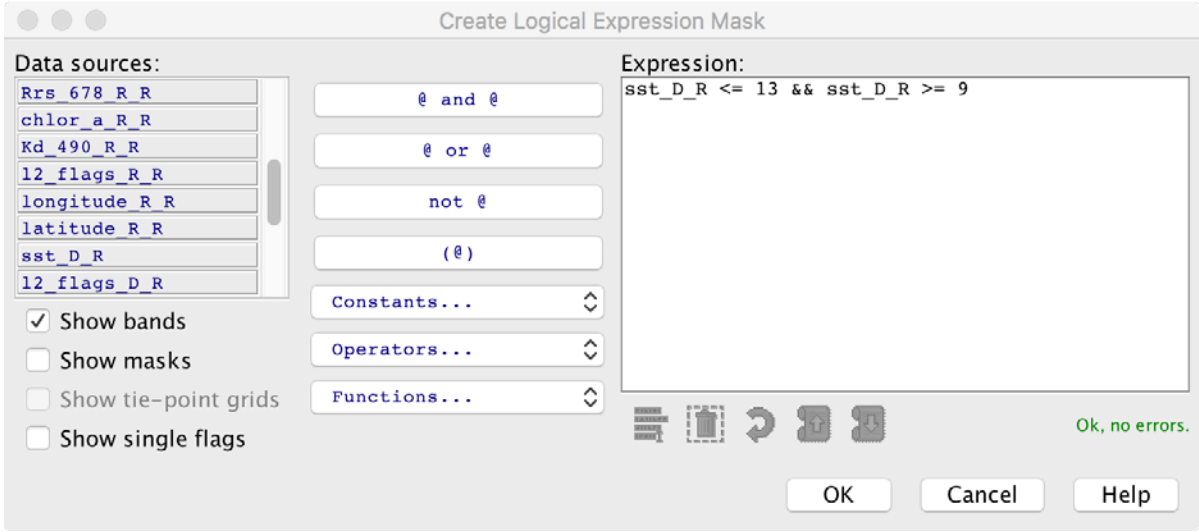
Statistics

Filter Band

Pixel Extraction

Combine (Mosaic) Two Images

7. Enter the expression you see below



8. Click **OK**
9. Rename this new region of interest mask as ROI_1
10. Change its color so the ROI has high contrast with the underlying image

Statistics

Collocate Bands

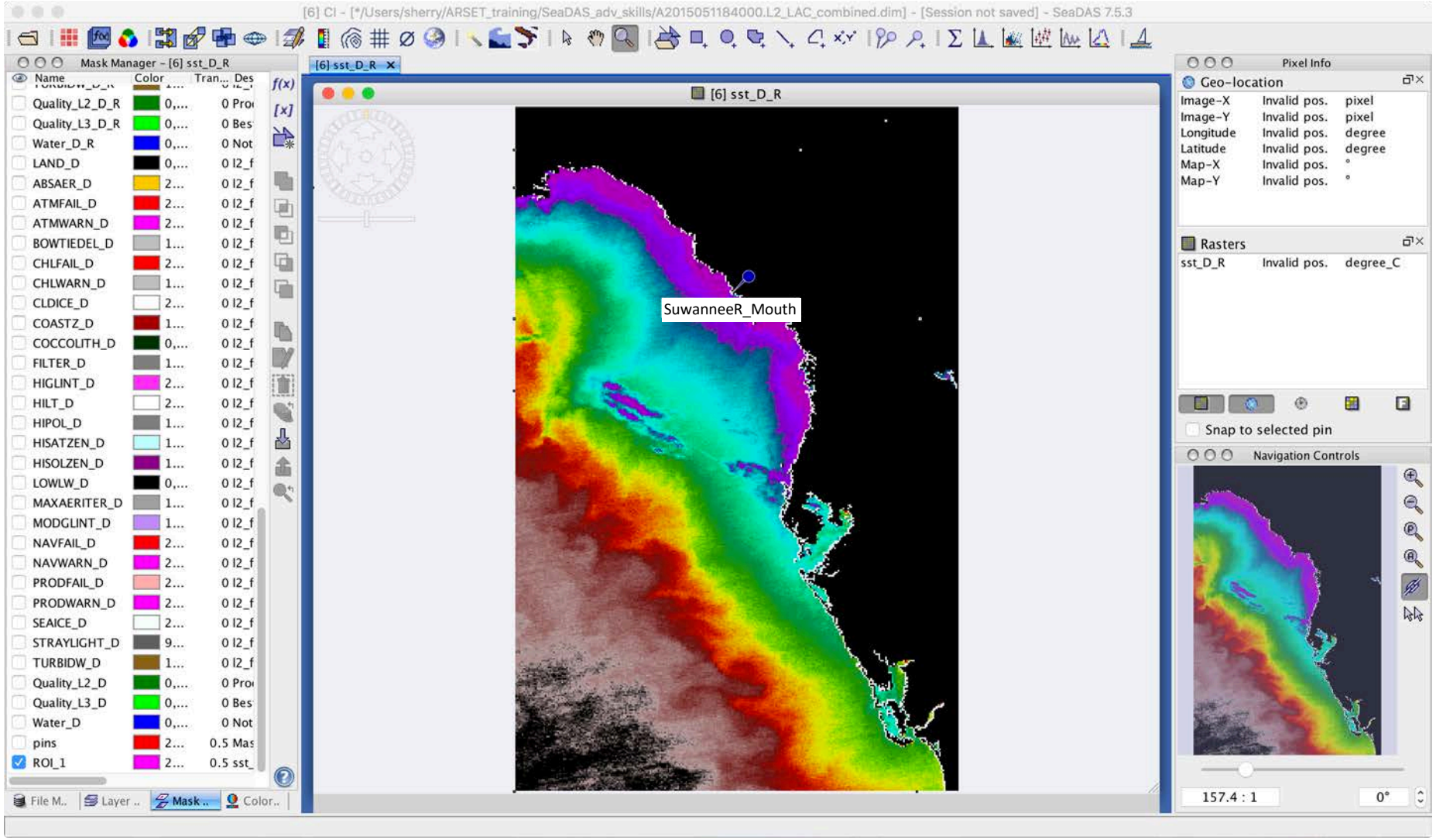
Band Math

Statistics

Filter Band

Pixel Extraction

Combine (Mosaic) Two Images



Statistics

Collocate Bands

Band Math

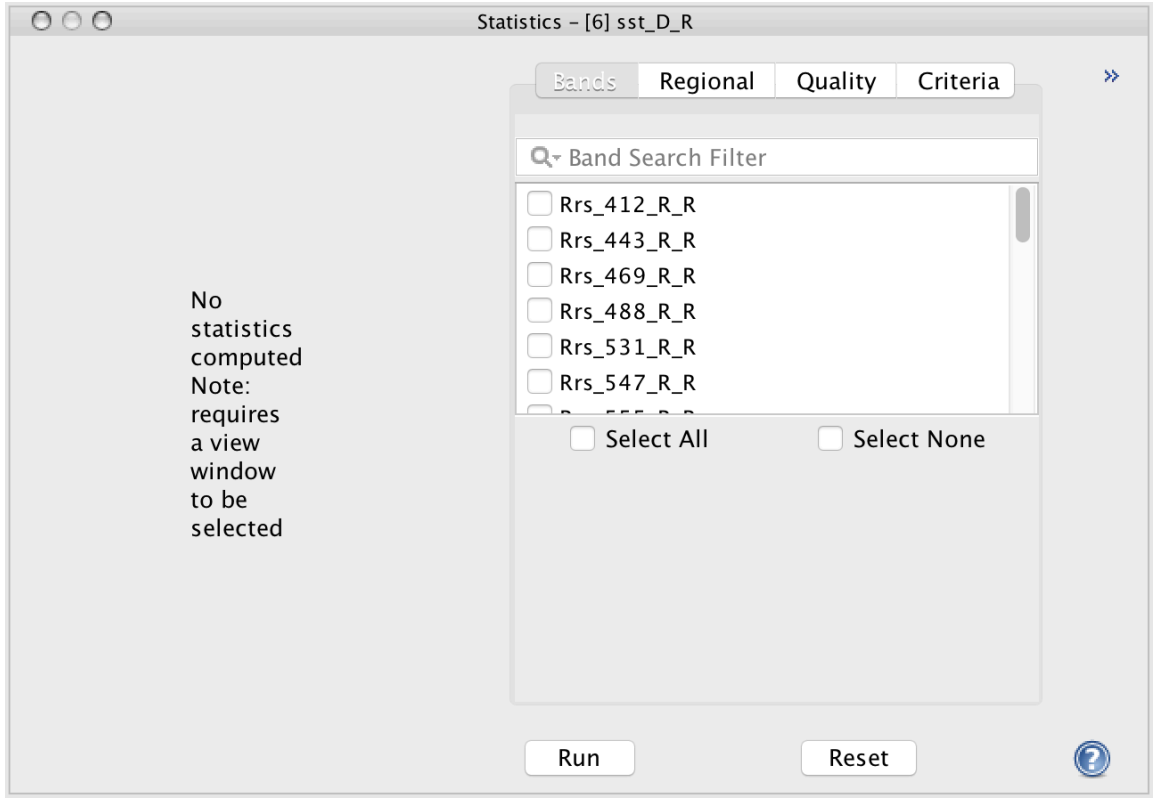
Statistics

Filter Band

Pixel Extraction

Combine (Mosaic) Two Images

11. Select the statistics tool on the toolbar. Σ This will open a window that at first will not have any statistics:



Statistics

Collocate Bands

Band Math

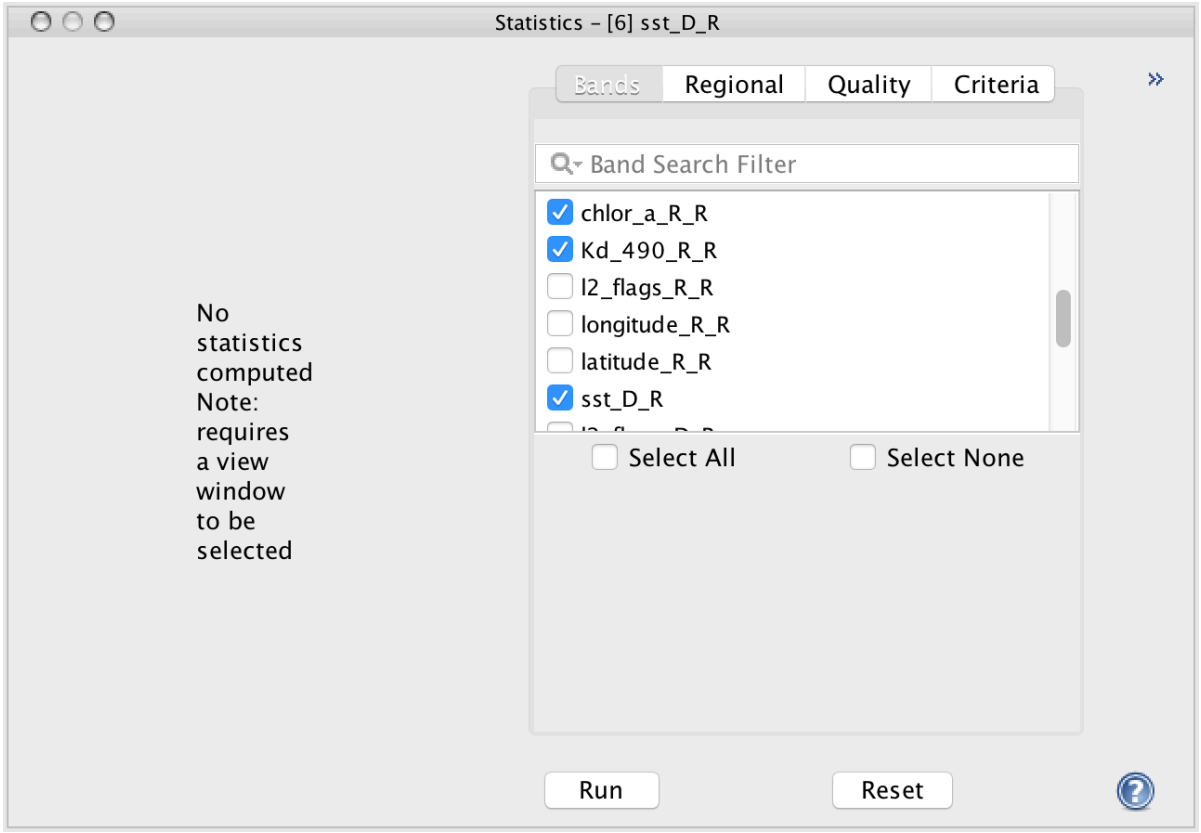
Statistics

Filter Band

Pixel Extraction

Combine (Mosaic) Two Images

12. You will need to make choices of what you would like to include in the statistics run. In this example, we will choose the bands:
    - chlor_a
    - SST
    - adg_443_giop
    - Kd_490



Statistics

Collocate Bands

Band Math

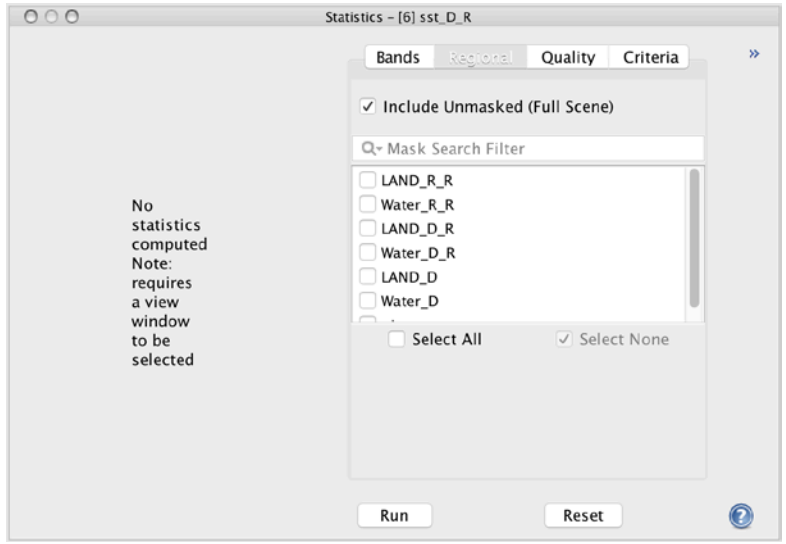
Statistics

Filter Band

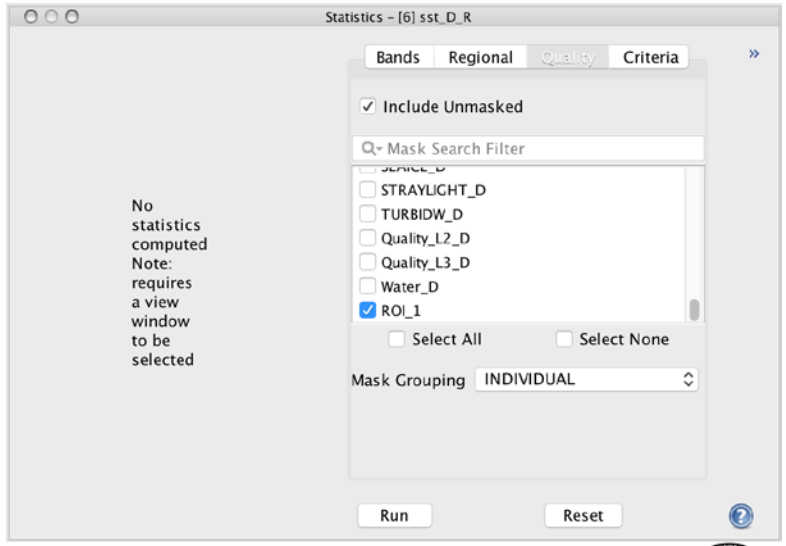
Pixel Extraction

Combine (Mosaic) Two Images

13. Click on **Regional** and leave the defaults as they are



14. Click on **Quality** and select the ROI_1 mask you just created



Statistics

Collocate Bands

Band Math

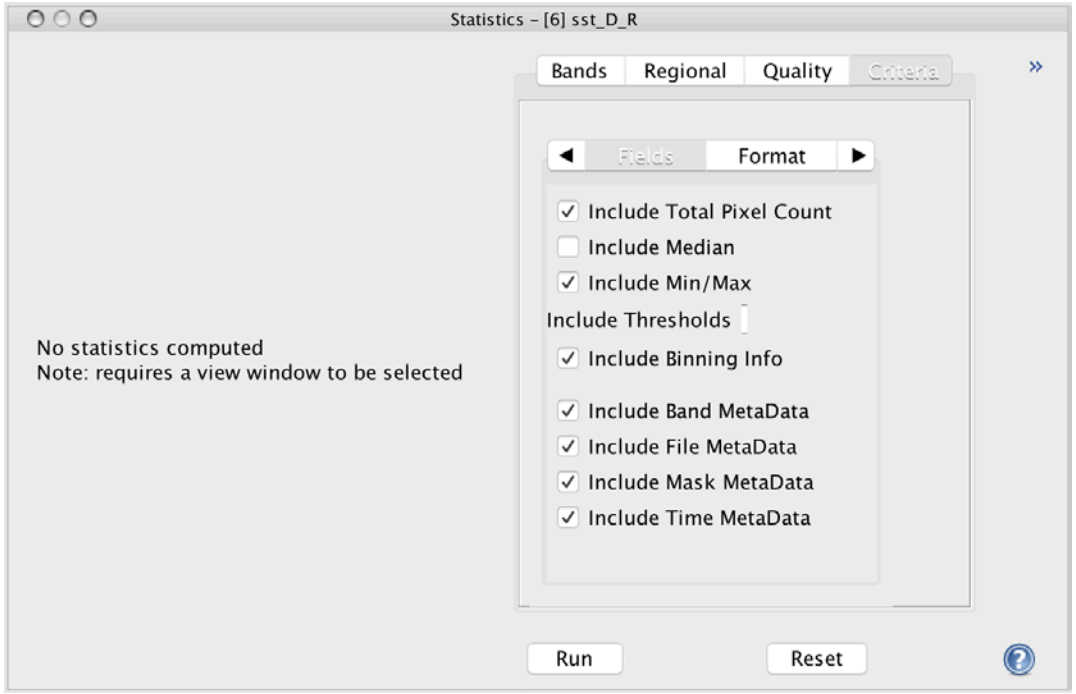
Statistics

Filter Band

Pixel Extraction

Combine (Mosaic) Two Images

15. Click on **Criteria**
16. Click on the **Fields** button and turn on **Include Min/Max**



17. Review the settings and click **Run**

Statistics

Collocate Bands

Band Math

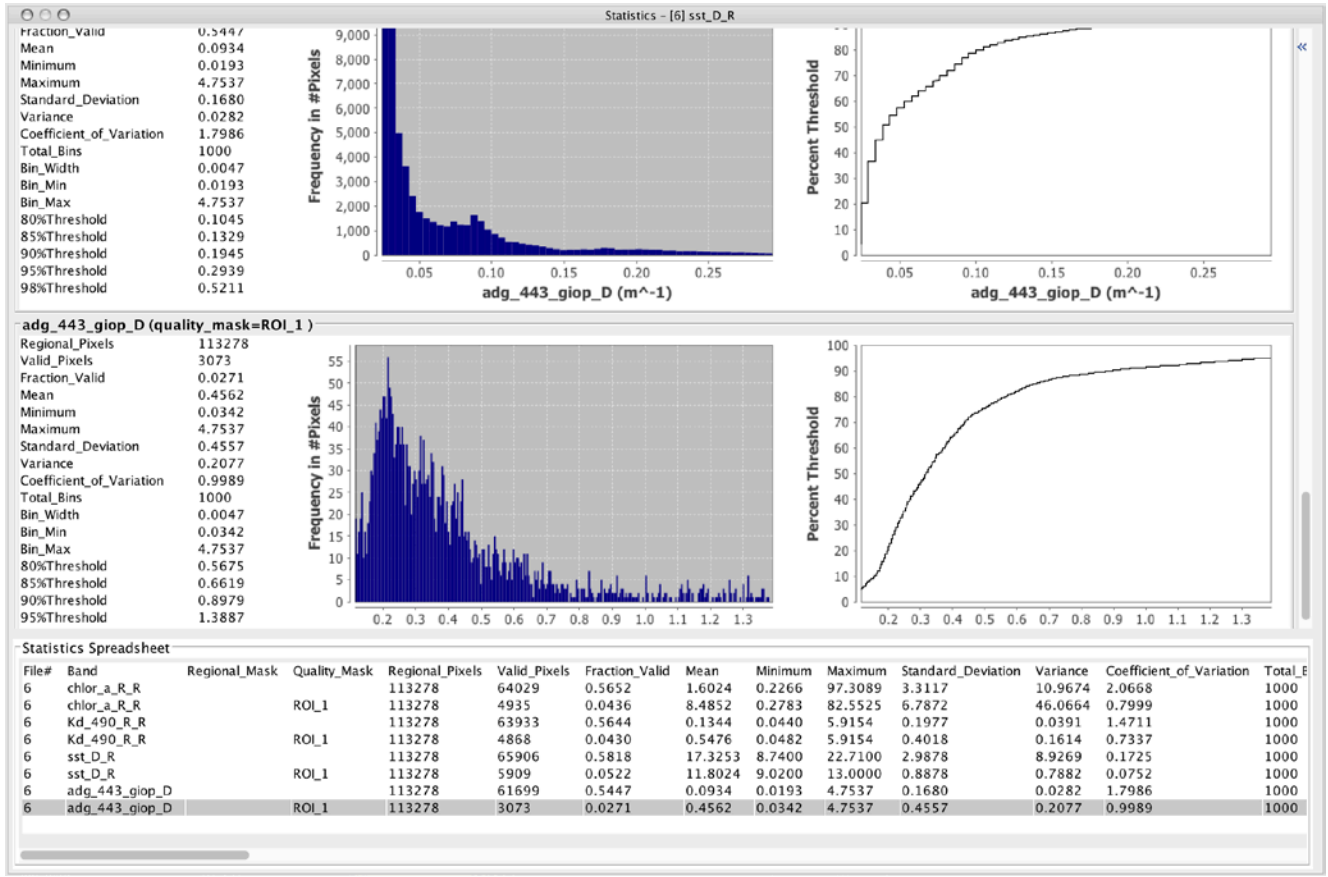
Statistics

Filter Band

Pixel Extraction

Combine (Mosaic) Two Images

- The output should automatically populate the statistics window
- Explore this window – scroll along the right to see both sets of figures



Statistics

Collocate Bands
Band Math
Statistics
Filter Band
Pixel Extraction
Combine (Mosaic) Two Images

- These are the statistics for the full scene and the scene bounded by the ROI_1 mask
- Because the ROI_1 mask is so large, the shapes of the figures are similar
- Look closely at the statistics output at the bottom in the statistics spreadsheet pane. Look for adg_443_giop and you will see the number of “Valid_pixels” for the full scene is greater than for the ROI_1 mask. The statistics for ROI_1 are being computed on a subset of the full scene.

Statistics

Collocate Bands

Band Math

Statistics

Filter Band

Pixel Extraction

Combine (Mosaic) Two Images

- Remember, adg_443_giop is an estimate of light absorption by detrital matter (d) and colored dissolved organic matter (CDOM)
- The Suwannee River is a “blackwater river” and carries high concentrations of CDOM
- Before the river plume fully mixes with the surrounding waters and warms to their temperatures, this high adg_443 signature is notable and indicative of low salinity water

Statistics

Collocate Bands
Band Math
Statistics
Filter Band
Pixel Extraction
Combine (Mosaic) Two Images

- Light absorption by CDOM can be used as a proxy for low salinity water in coastal systems
- Every river system has a unique CDOM-salinity signature
- It is important that if you are developing a CDOM-salinity algorithm that you create the algorithm using in situ measurements from the region of interest

Statistics

Collocate Bands

Band Math

Statistics

Filter Band

Pixel Extraction

Combine (Mosaic) Two Images

18. Close the statistics window
19. We'll use the scatterplot tool as a way to explore relationships between variables. Click on the **Scatterplot Tool** icon
20. The scatter plot window will open. Use the ROI mask **Water_D**, **sst_D_R** for the x-axis and **adg_443_giop_D** for the y-axis
21. Click on the **Refresh View** icon

Statistics

Collocate Bands

Band Math

Statistics

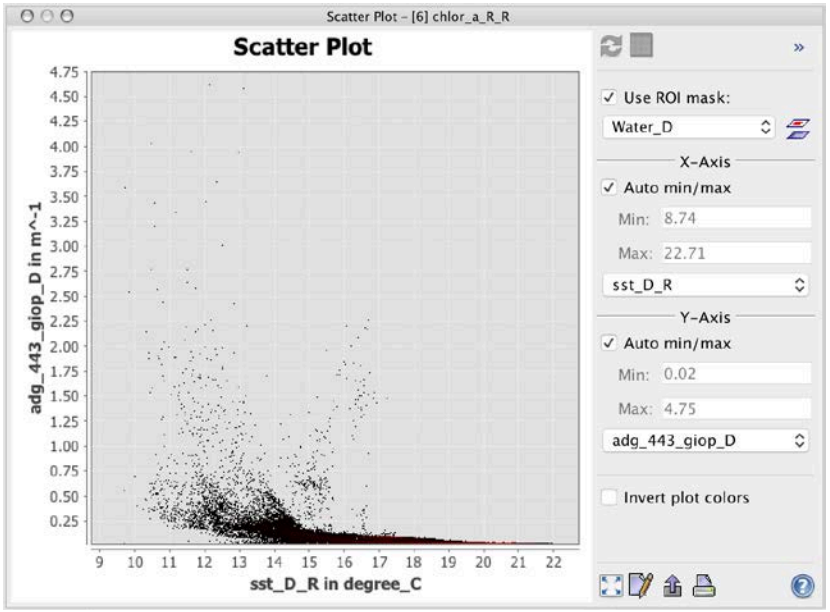
Filter Band

Pixel Extraction

Combine (Mosaic) Two Images

- This plot shows a scatter plot for the entire water area, not just the masked area
- As temperature decreases, adg_443_giop increases
- This plot shows the relationship of temperature to light absorption by CDOM described in the previous section

22. Close the Scatter Plot window



Filter Band

Collocate Bands

Band Math

Statistics

Filter Band

Pixel Extraction

Combine (Mosaic) Two Images

- The filter band creates a band by applying a convolution or non-linear filter to an existing band
- This tool can be used to enhance features in an image
- SeaDAS has a number of filter options, as well as the option for user-supplied filters
- Options for filters include functions to
  - smooth and blur the image
  - adjust for stray light
  - detect lines and gradients
  - sharpen
  - enhance discontinuities
  - apply a number of non-linear and morphological filters

Filter Band

Collocate Bands

Band Math

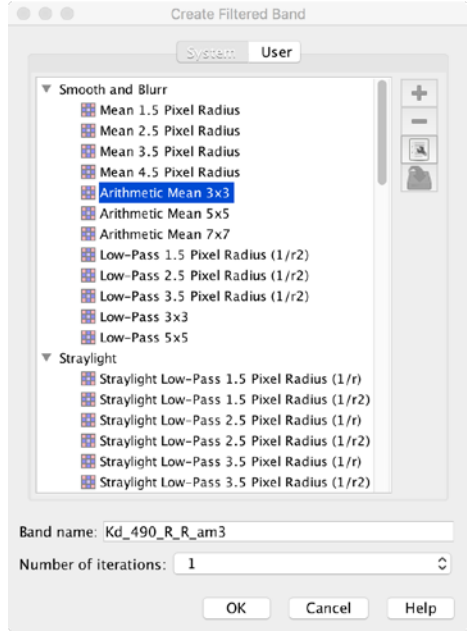
Statistics

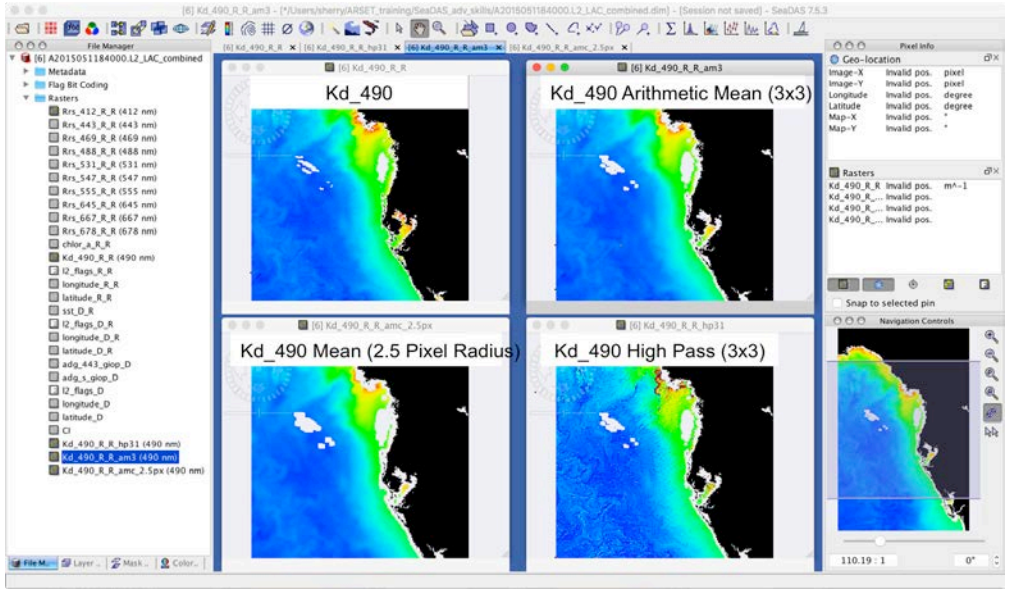
Filter Band

Pixel Extraction

Combine (Mosaic) Two Images

1. To use the tool, click **Raster** > **Filtered Band** to open the **Create Filtered Band** window
2. Below are some examples of filters applied to the KD_490 band. Try a few band filter methods to gain an understanding of how they modify the data
3. When finished, close all of the image windows





Pixel Extraction

Collocate Bands

Band Math

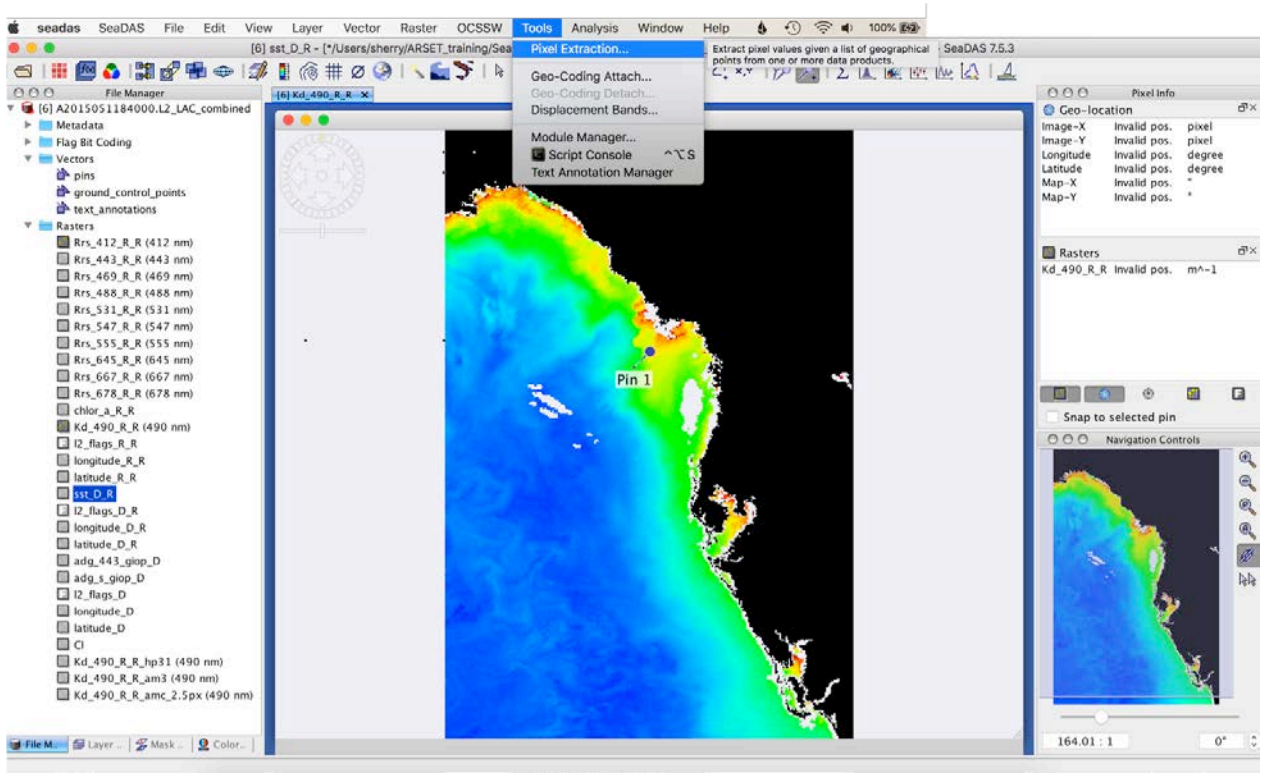
Statistics

Filter Band

Pixel Extraction

Combine (Mosaic) Two Images

1. Double click on the chlor_a image layer
2. Using the pin tool, drop a pin into the scene
3. Launch the Pixel Extraction tool via **Tools** > **Pixel Extraction**



Pixel Extraction

Collocate Bands

Band Math

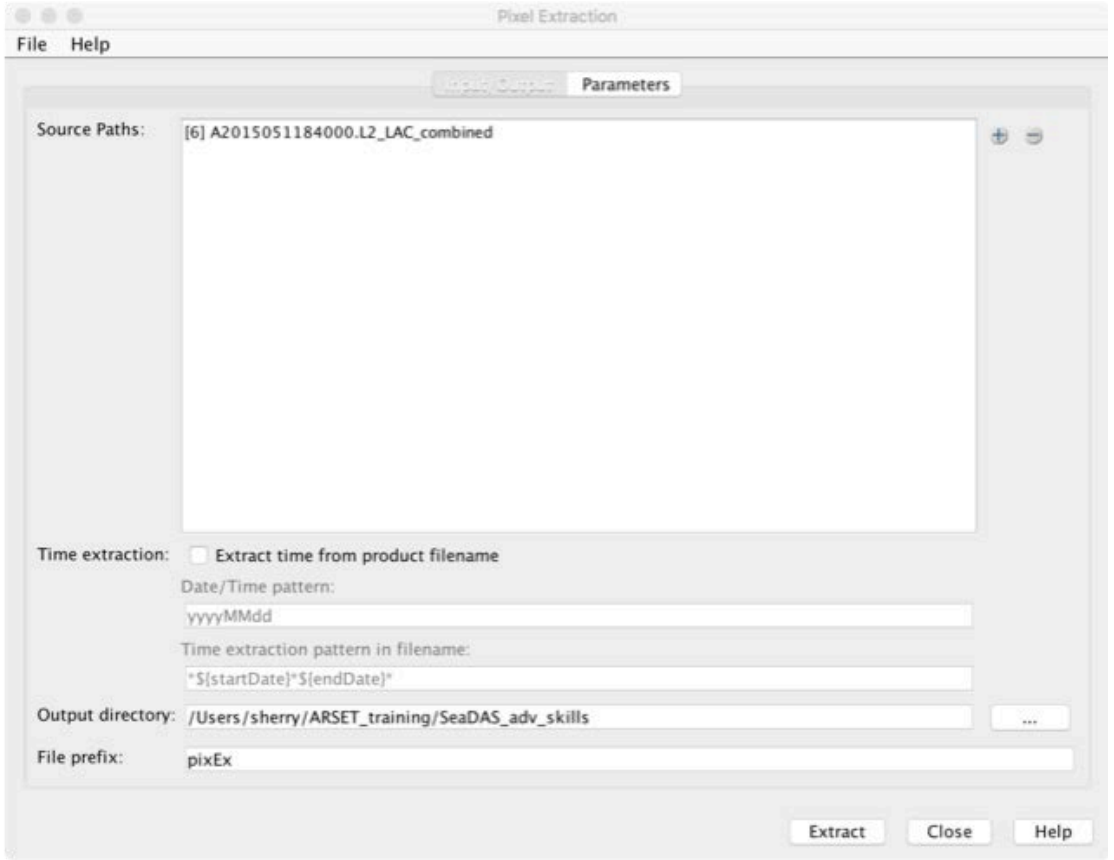
Statistics

Filter Band

Pixel Extraction

Combine (Mosaic) Two Images

4. This will open a new window. On the **Input/Output** tab, update the entries for **Output Directory**



Pixel Extraction

Collocate Bands

Band Math

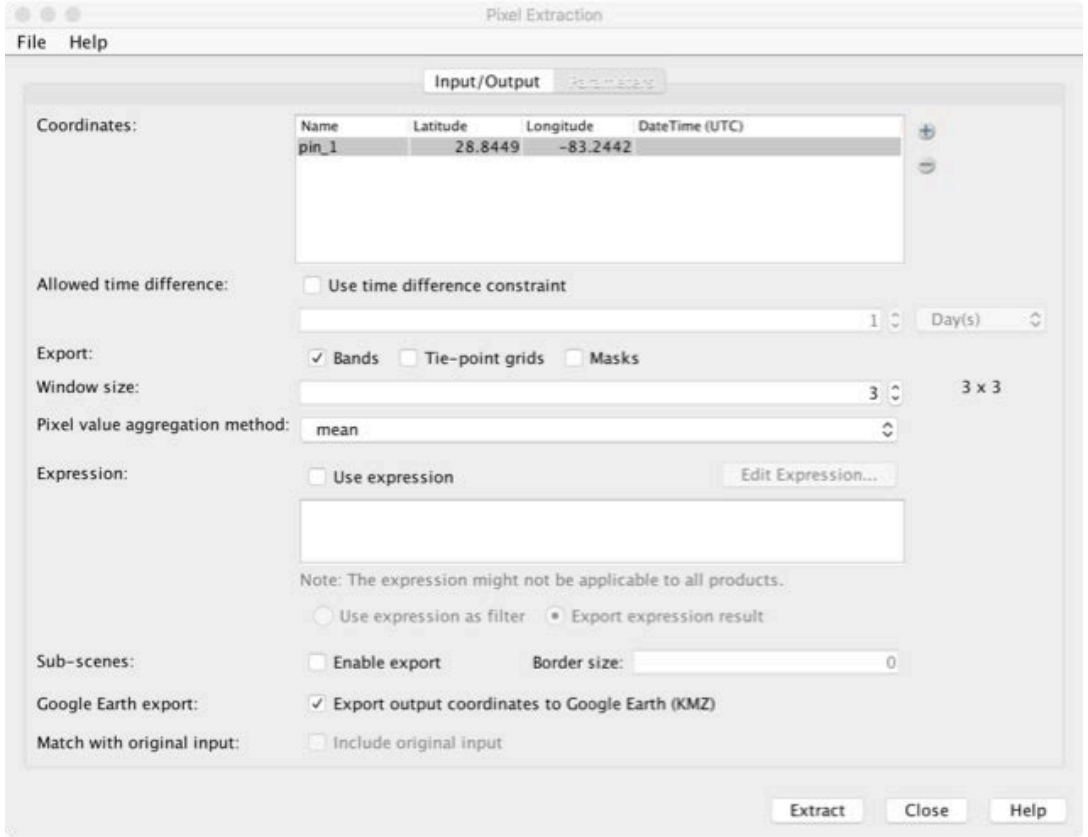
Statistics

Filter Band

Pixel Extraction

Combine (Mosaic) Two Images

5. On the **Parameters** tab, change the window size to a 3x3 pixel box
6. Choose a pixel value aggregation method as mean
7. De-select tie-points grids and masks
8. When satisfied with your choices, click **Extract**



Pixel Extraction

Collocate Bands

Band Math

Statistics

Filter Band

Pixel Extraction

Combine (Mosaic) Two Images

- This produces an output text file, which you may wish to open using spreadsheet software
- This example only shows pixel extraction using a pin
- It is also possible to provide a table of coordinates for the extraction of multiple locations

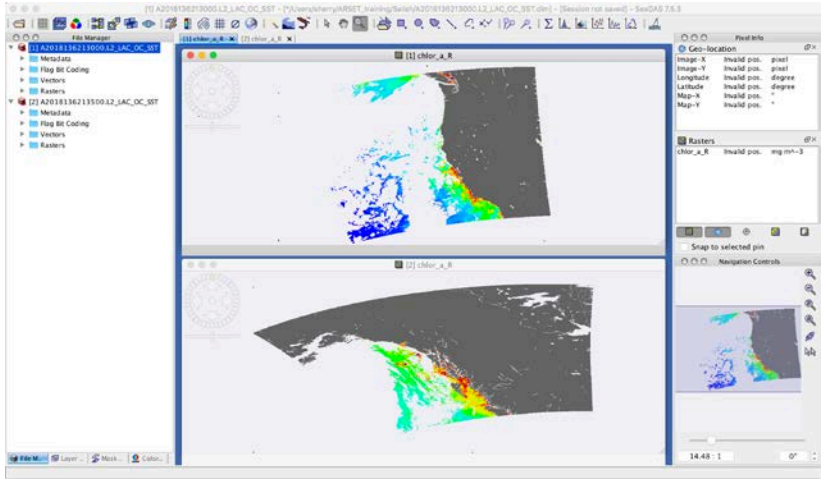
9. Save and close the file

	A	B
1	# BEAM pixel extraction export table	
2	#	
3	# Window size: 3	
4	# Created on:	5/9/19 9:02
5		
6		
7	ProdID	0
8	CoordID	1
9	Name	pin_1
10	Latitude	28.844902
11	Longitude	-83.244217
12	PixelX	125.5
13	PixelY	157.5
14	Date(yyyy-MM-dd)	2/20/15
15	Time(HH_mm_ss)	18:42:30
16	Rrs_412_R_R_mean	0.00245422
17	Rrs_412_R_R_sigma	2.80E-04
18	Rrs_412_R_R_num_pixels	9
19	Rrs_443_R_R_mean	0.00439933
20	Rrs_443_R_R_sigma	3.91E-04
21	Rrs_443_R_R_num_pixels	9
22	Rrs_469_R_R_mean	0.00653422
23	Rrs_469_R_R_sigma	4.73E-04
24	Rrs_469_R_R_num_pixels	9
25	Rrs_488_R_R_mean	0.00790978
26	Rrs_488_R_R_sigma	5.73E-04
27	Rrs_488_R_R_num_pixels	9
28	Rrs_531_R_R_mean	0.00964267
29	Rrs_531_R_R_sigma	7.05E-04
30	Rrs_531_R_R_num_pixels	9
31	Rrs_547_R_R_mean	0.00966578
32	Rrs_547_R_R_sigma	7.15E-04
33	Rrs_547_R_R_num_pixels	9
34	Rrs_555_R_R_mean	0.00904067

Combine (Mosaic) Two Images

Collocate Bands
Band Math
Statistics
Filter Band
Pixel Extraction
Combine (Mosaic) Two Images

- We'll demonstrate the last section with images from the Salish Sea region of northwest Washington State, U.S. and southwest British Columbia, Canada
- The files used in this section include:
  - A2018136213000.L2_LAC_OC_SST.dim (and supporting .data file)
  - A2018136213500.L2_LAC_OC_SST.dim (and supporting .data file)
- These are reprojected, collocated files of the region that include ocean color and sea surface temperature
- The region of interest is the greater Salish Sea, but one image did not capture the entire region. There is a need to mosaic two images together.



Combine (Mosaic) Two Images

Collocate Bands

Band Math

Statistics

Filter Band

Pixel Extraction

Combine (Mosaic) Two Images

1. Find and click the Mosaic tool on the toolbar
2. A window will open. Click the plus sign under **Source Files** and add the two collocated files
3. Enter a new name for the output file
4. Choose the directory path to the folder containing the original data for this scene

Combine (Mosaic) Two Images

Collocate Bands

Band Math

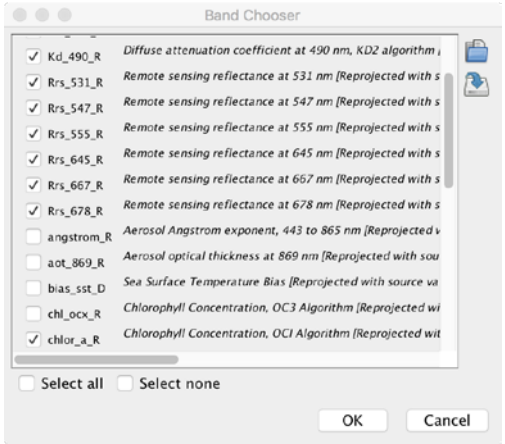
Statistics

Filter Band

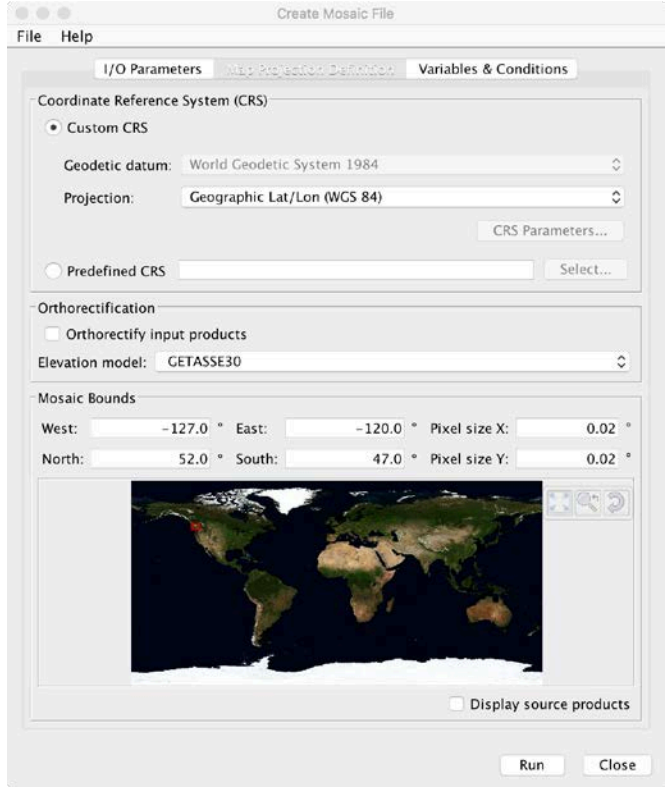
Pixel Extraction

Combine (Mosaic) Two Images

5. Click on the **Map Projections Definitions** tab
6. Edit the mosaic bounds to subset the mosaicked image to the region of interest
7. Click on the **Variables & Conditions** tab
8. Just below **Variables**, click on the **Choose bands to process** icon to open this window



9. Select all of the R_{rs} bands, chlor_a, SST, Kd_490 and any other bands of interest
10. Return to the **Variables & Conditions** window



Combine (Mosaic) Two Images

Collocate Bands

Band Math

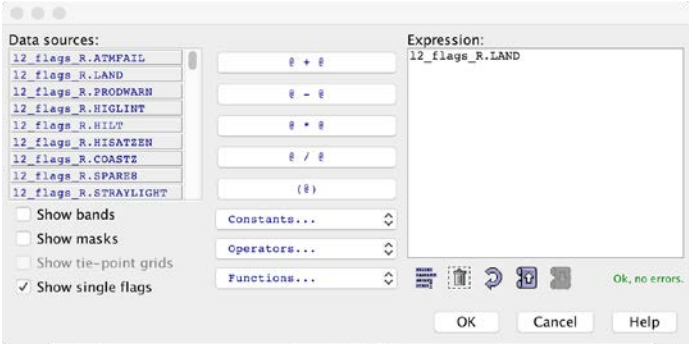
Statistics

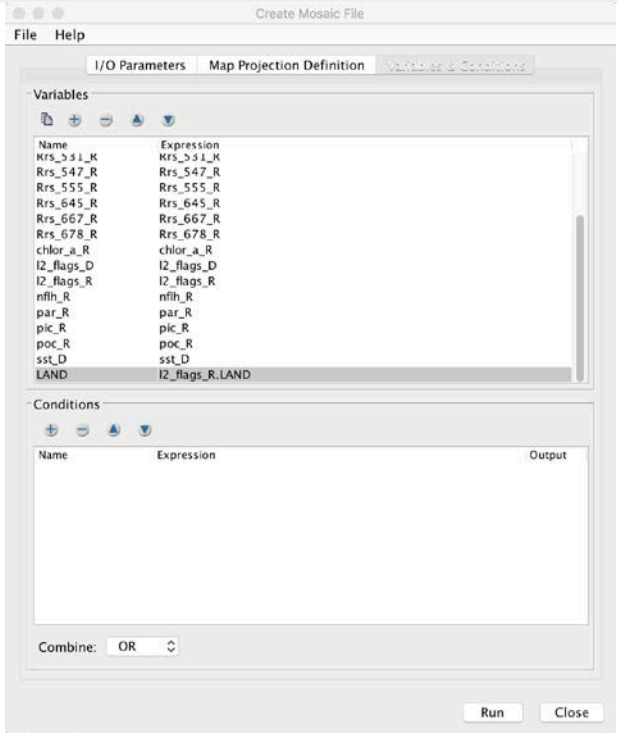
Filter Band

Pixel Extraction

Combine (Mosaic) Two Images

11. Under **Variables**, click on the plus sign and scroll to the bottom of the list of data products
12. Name the new variable, LAND, and then click on the ellipses to the right of the **Expression** box
13. This will open the **Expression Editor**
14. Click the button next to **Show single flags**
15. Select l2_flags_R.LAND
16. Click **OK**
17. Click **Run**
18. When it is completed, the new file will appear in the File Manager. Close the mosaic tool.





Combine (Mosaic) Two Images

Collocate Bands

Band Math

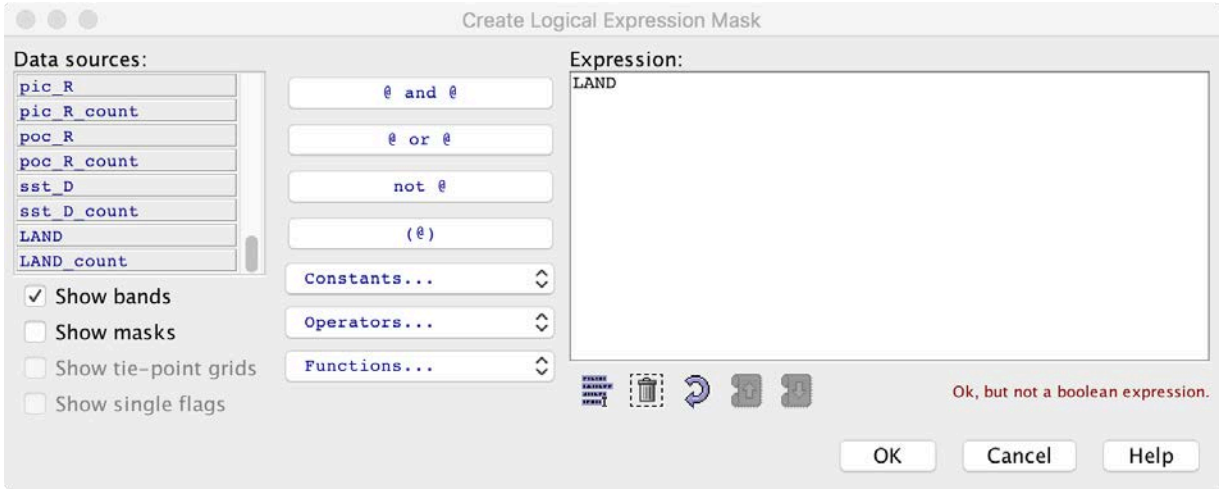
Statistics

Filter Band

Pixel Extraction

Combine (Mosaic) Two Images

19. If you click on the Layer Manager, it will be empty. We need to manually add the land mask to the file. On the left side of the viewer, click on the **Mask Manager** tab.
20. Click on the **Create a new mask based on math icon** f(x)
21. This will open the **Create Logical Expression Mask**
22. Scroll through the data sources to the LAND band and select it
23. Click **OK**



Combine (Mosaic) Two Images

Collocate Bands

Band Math

Statistics

Filter Band

Pixel Extraction

Combine (Mosaic) Two Images

24. This will cause a new mask to appear in the Mask Manager. Double click on the name and change it to **LAND**
25. Double click on the color and change it to black
26. Double click on **Transparency** and change it to zero
27. Return to the **File Manager** and open chlor_a_R
28. Go to the **Layer Manager** and turn on the LAND mask by clicking the button next to it
29. Right click on the mosaic file in the **File Manager** and select **Save As**
30. Overwrite the existing file to preserve the land mask you just created
31. Close the original two files used to create the mosaicked file
32. Congratulations on creating a mosaic!