Monitoring Coastal and Estuarine Water Quality Using Remote Sensing and In Situ Data

Exercise 2

Prerequisites

- Installation of OCSSW on your computer
- MODIS and VIIRS chlorophyll data from Exercise-1
- SeaBASS and GCOOS in situ data from Exercise-1

Objectives

By the end of this exercise, participants will be able to:

- Compare/Validate MODIS and VIIRS chlorophyll data with SeaBASS in situ data
- Process MODIS and VIIRS Level-2 data from Level-1 using SeaDAS/OCSSW
- Generate algorithm coefficients from MODIS and VIIRS reflectance data and GCOOS observations*

*This last exercise is optional

Important Note

- This exercise is to learn water quality data validation and algorithm generation using sample data and will **not** yield statistically significant results!
- In practice, many more observations are required for the validation and algorithm generation from remote sensing and in situ data.

Download the Data Required for this Exercise

Download **Exercise-2_Datafiles** from the training webpage.

- **[1]Level-2 chlorophyll mosaic images from Exercise-1:**

  A20171011-mosaic.dim (for MODIS)
  A20171011-mosaic.data (for MODIS)
  V20171011-mosaic.dim (for VIIRS)
  V20171011-mosaic.data (for VIIRS)

- **Level-1A images:**
  A2017284181500.L1A_LAC (MODIS)
  V2017284191200.L1A_SNPP.nc (VIIRS)

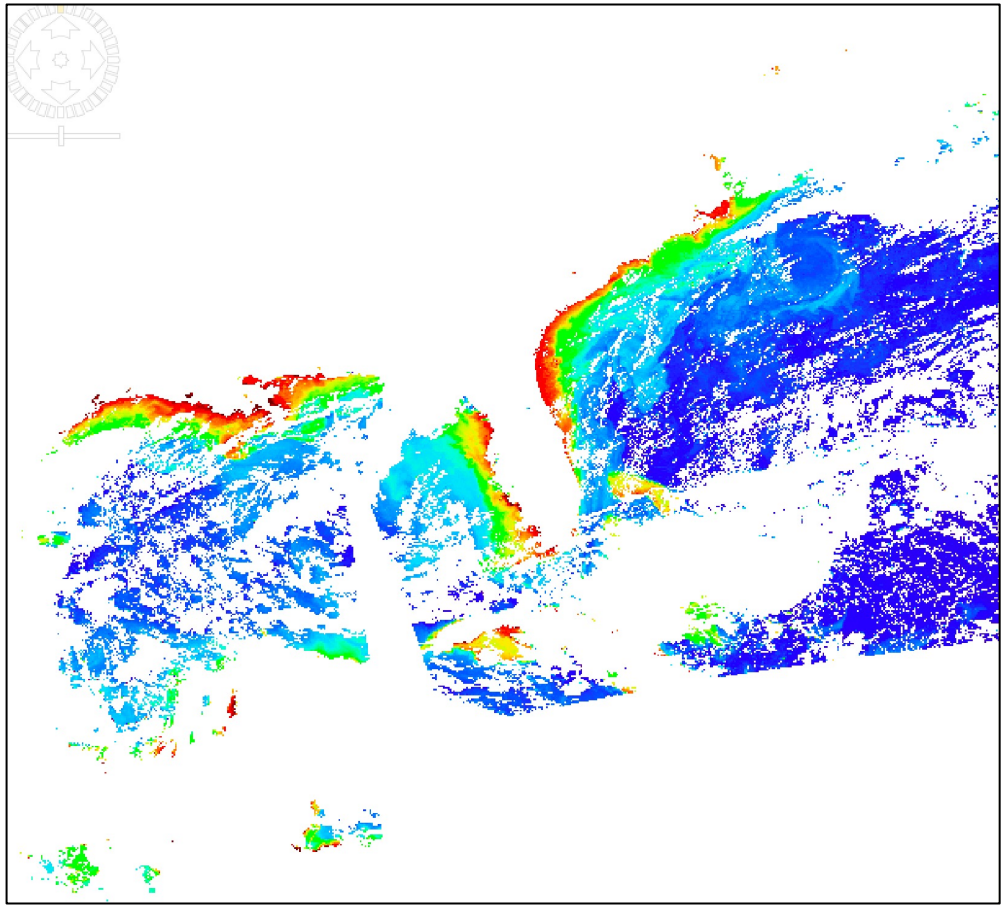
- **[1]SeaBASS in situ data from Exercise-1:**
  e29f6ffdc2_ntb1_chl.sb

- **[1]GCOOS in situ data file:**
  GCOOS_20171011.sb

[1]These files are from Exercise-1

Open MODIS Image

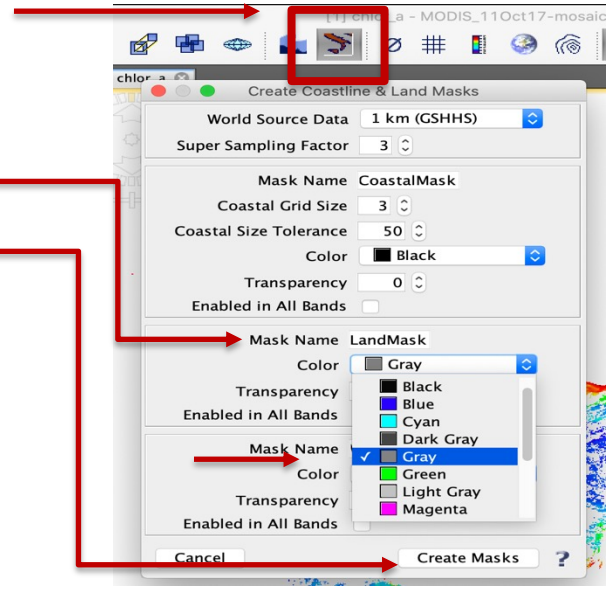
1. In the SeaDAS window.
   - On the top ribbon go to **File → Open Product** and select **A20171011-mosaic.dim**. You will see the MODIS file name in the **File Manager**.
   - Click on the down arrow next to the file name **A20171011-mosaic → Bands → chlor-a**.
   - Double-click on **chlor-a** to get the image.



Note: Steps 1-6 are from Exercise-1

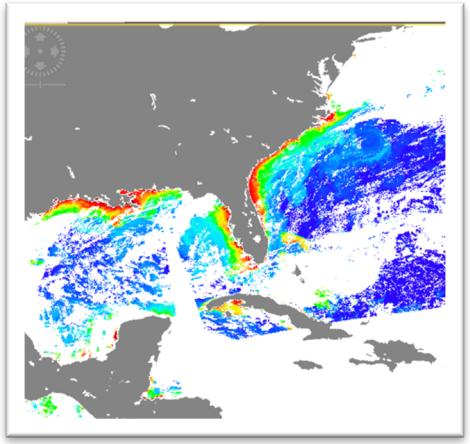
Add Land Mask to the MODIS Image

2. Click on the "Add coastline, land and water masks" icon  on the top menu bar:
   - Under **Mask Name → LandMask**, using the drop-down arrow select **Gray** and click on **Create Masks**.
   - You will get the MODIS image with the land mask.

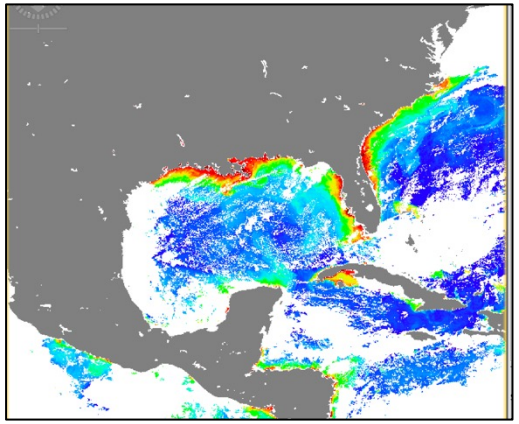


3. Repeat Steps 1 and 2 for the VIIRS image: **V20171011.mosaic.dim**.

MODIS

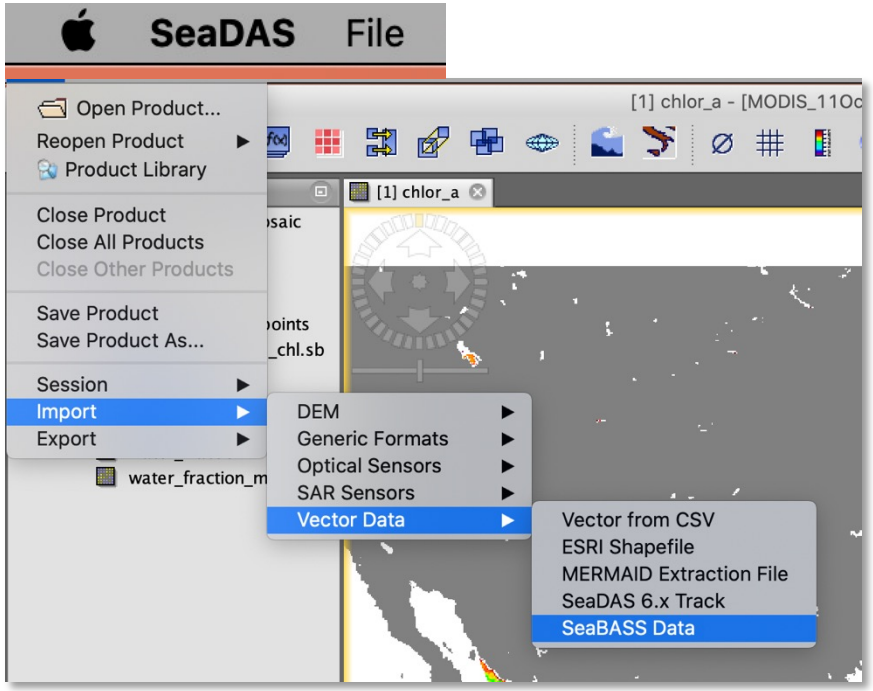


VIIRS



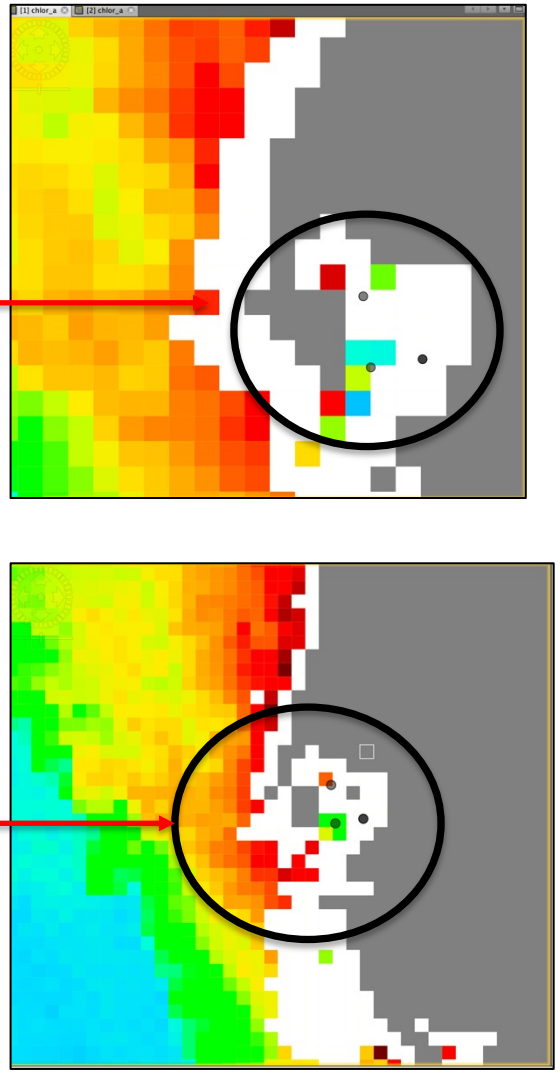
Add SeaBASS Chlorophyll Data to the MODIS Image

4. In the **File Manager** panel highlight **chlor_a**:
   - From the top ribbon click on **File → Import → Vector Data → SeaBASS Data**.
   - Navigate to the file **e29f6ffdc2_ntb1_chl.sb** and click on **Open** to add the SeaBASS data.



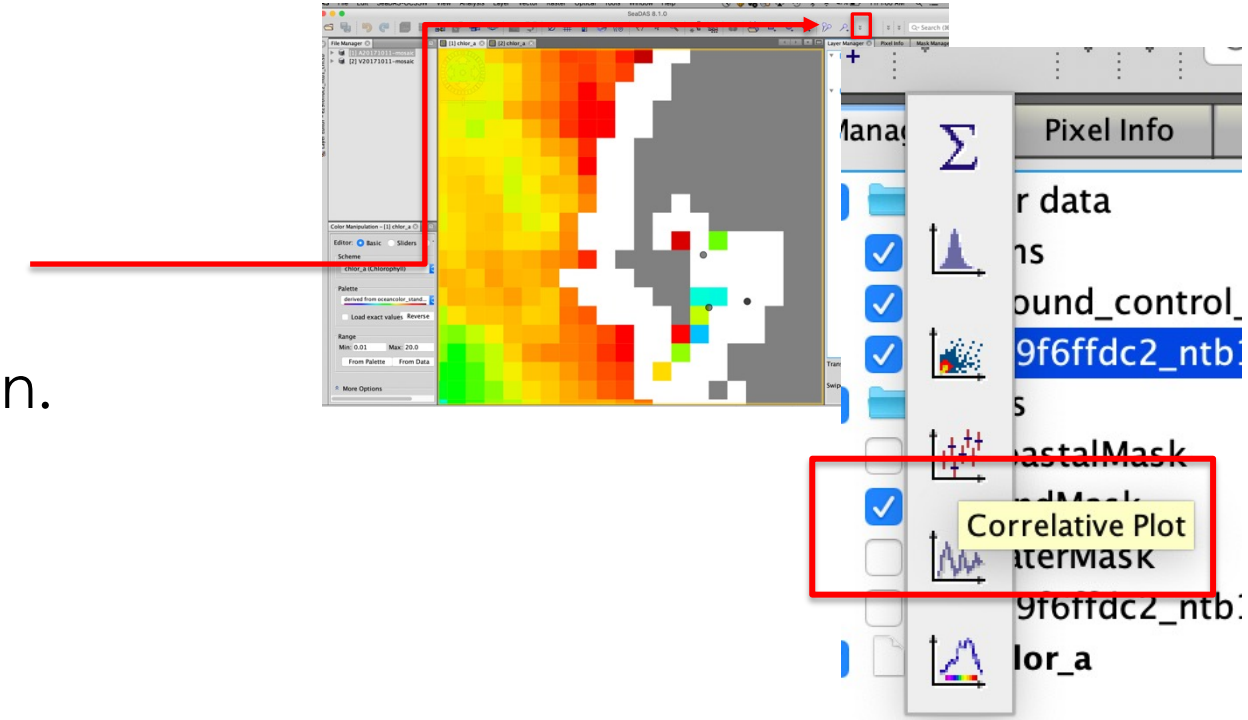
Add SeaBASS Chlorophyll-a Data to MODIS & VIIRS Images

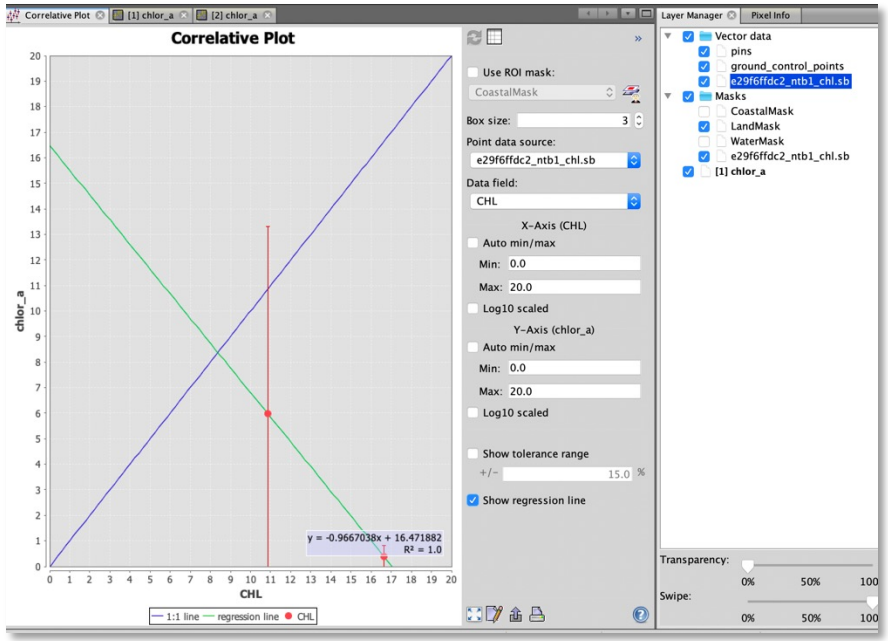
5. SeaBASS data locations will be added to the image.
   - To change the symbology (i.e., symbol and color) of the SeaBASS locations, select **Layer Manager → Vector data → SeaBASS filename (e29f6ffdc2_ntb1_chl.sb)**.
   - From the top ribbon go to **Layer → Layer Editor**.
   - In the **Layer Editor** window change **Fill** and **Stroke** to desired color and choose a **Symbol** to display.
6. Repeat Steps 4 & 5 for the VIIRS image **V20171011-mosaic.dim**.



Compare MODIS and SeaBASS Chlorophyll Data

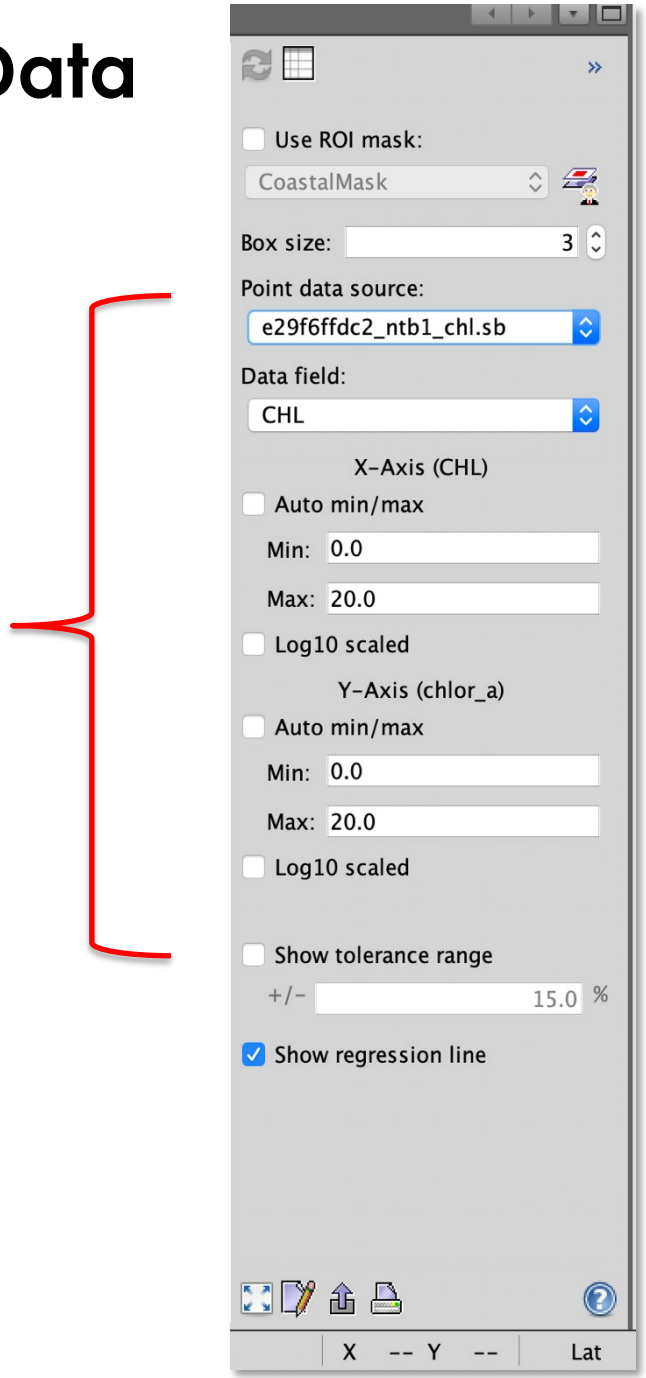
7. Click on the MODIS chlor_a image.
   - From the SeaDAS Ribbon, click the first set of down arrows to find the **Correlative Plot**.
   - The **Correlative Plot** window will open.





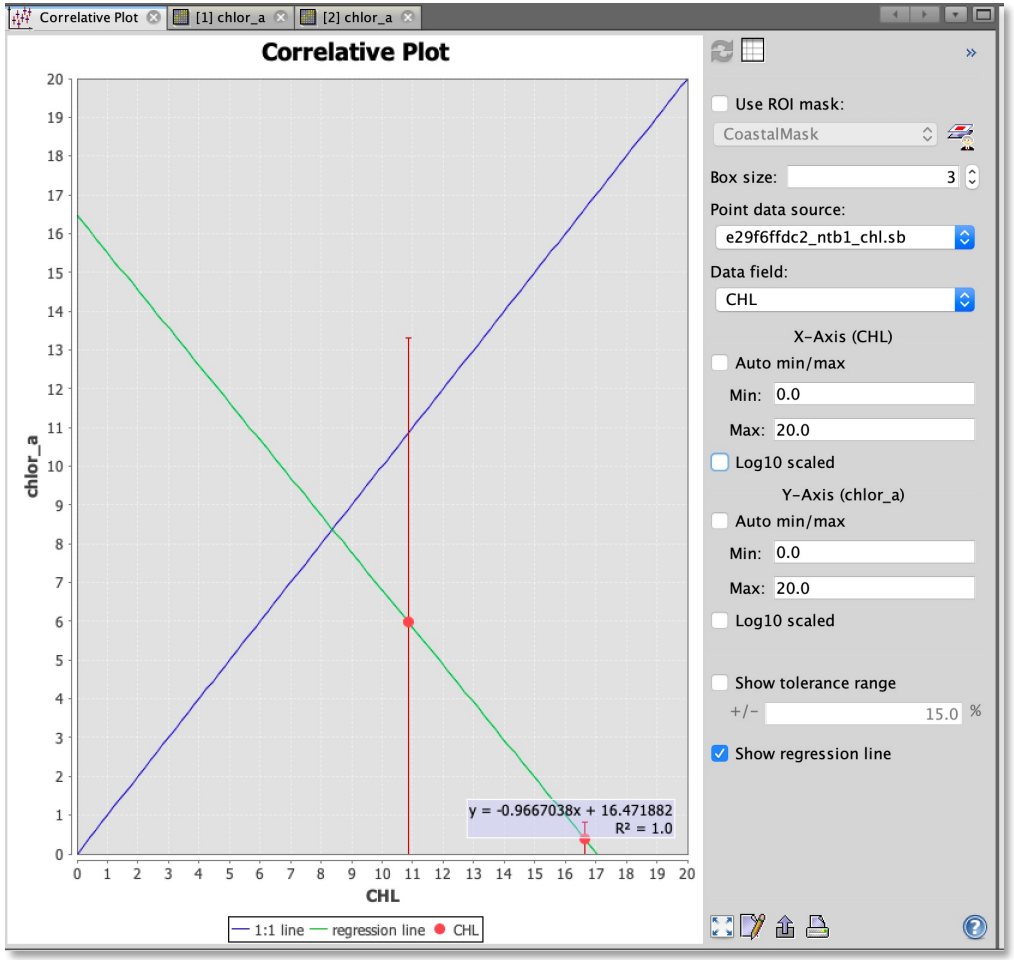
Compare MODIS and SeaBASS Chlorophyll Data

8. In the **Correlative Plot** go to **X-Axis & Y-Axis (chlor_a)** selection window:
   - Select **Box size** of 3.
   - For **Point data source** select **e29f6ffdc2_ntb1_chl.sb**.
   - For **Data field** select **CHL**.
   - Set **X-Axis (CHL) min and max** to **0** and **20**.
   - Set **Y-Axis (chlor_a) min and max** to **0** and **20**.
   - Select **Show regression line**.



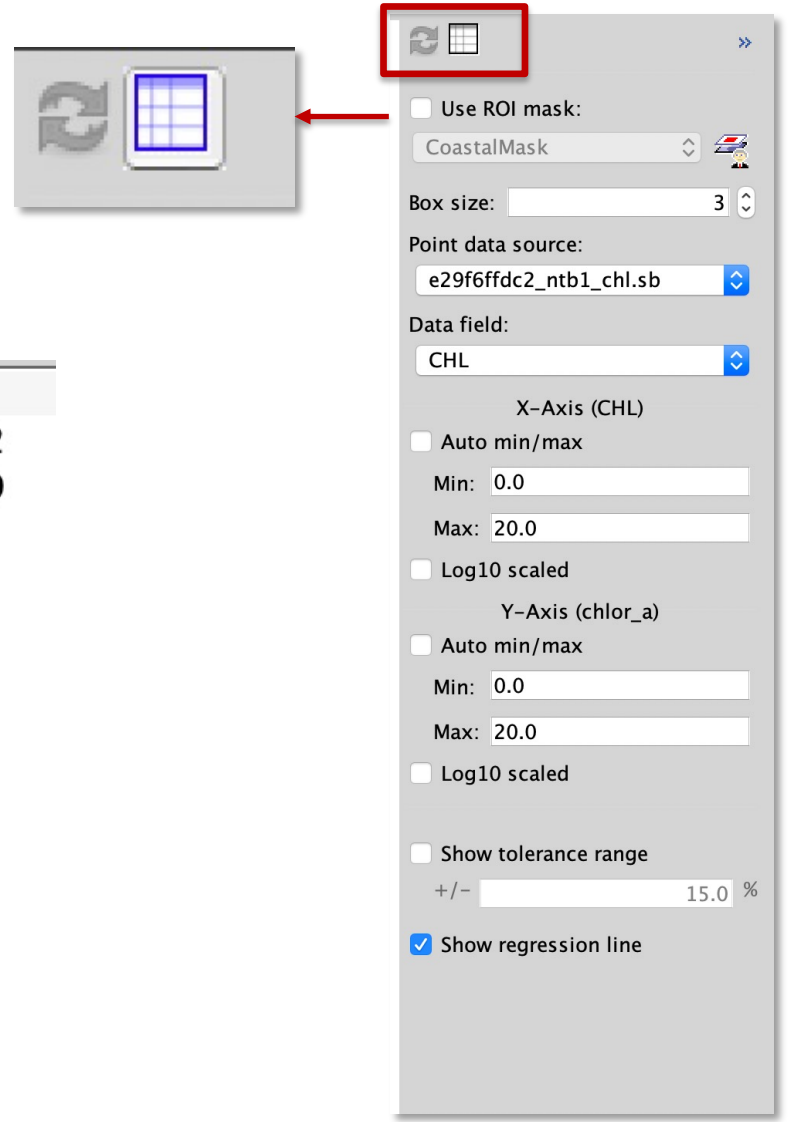
Compare MODIS and SeaBASS Chlorophyll Data

9. MODIS and SeaBASS chlorophyll data points will be plotted.
   - There are four SeaBASS data points in the file, but the correlative plot shows only two in situ points. Why?
   - Take note of the regression relation and correlation coefficient R^2.



Compare MODIS and SeaBASS Chlorophyll Data

10. At the top of the X-Y Selection Window, click on the Table view next to the double arrow to get values for each point.



pixel_x	pixel_y	latitude	longitude	chlor_a_mean	chlor_a_sigma	CHL_ref
699.7038	337.26105	27.8897	-82.5874	5.9848866	7.332631	10.8482
700.0119	340.07104	27.7492	-82.572	0.38892832	0.42918816	16.6369

11. Note the differences between chlor_a_mean and CHL_ref.
12. Repeat Steps 7 to 11 for the VIIRS image.

Process MODIS and VIIRS Level-2 Data from Level-1 using SeaDAS/OCSSW

Acquiring MODIS and VIIRS Level-1A Images

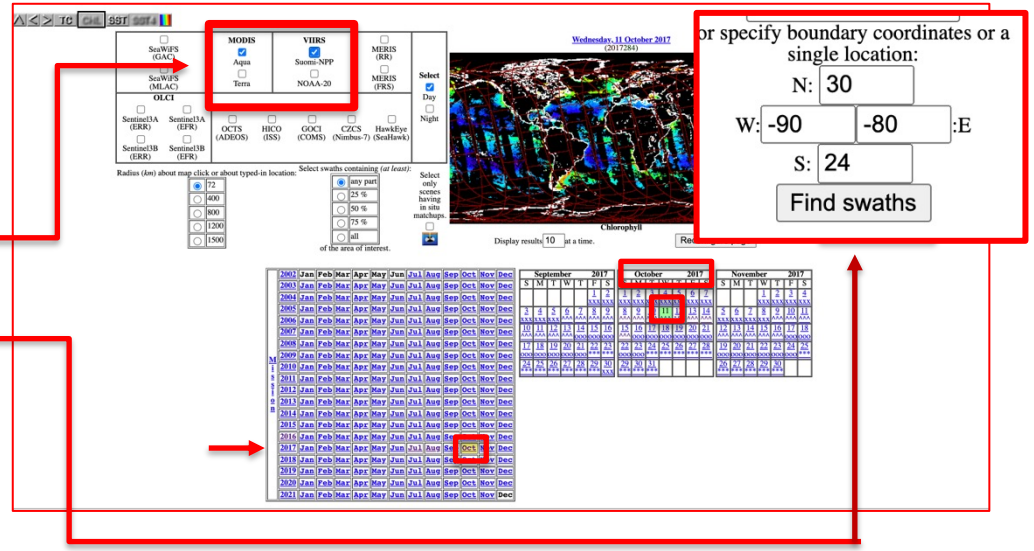
- MODIS and VIIRS L1A images can be obtained from NASA OceanColor Web.
- In Exercise-1, Level-2 Ocean Color data were downloaded (Steps 9 to 11). Bulk download procedure was demonstrated in the following webinar:

  Monitoring Coastal and Estuarine Water Quality: Transitioning from MODIS to VIIRS
  - https://appliedsciences.nasa.gov/join-mission/training/english/arset-monitoring-coastal-and-estuarine-water-quality-transitioning
- Based on the SeaBASS data locations, the spatial domain of the images can be selected.
- For this exercise, instead of entire Gulf of Mexico domain, a smaller domain is selected (next slide).

➢ **The next two slides provide the data selection and download instruction for your information, but for the exercise today, the images are made available to you and you can go directly to Step 16.**

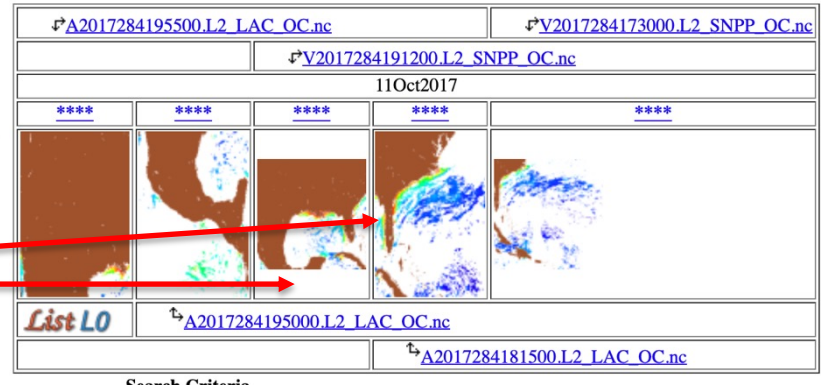
Acquiring MODIS and VIIRS Level-1A Images

13. Go to [NASA OceanColor Web](). Go to **Data → Level 1&2 Browser** and click on the map.
    - The data selection screen will open.
    - We will use 11 October 2017 for the case study:
      - In the **Mission** window, Click **2017** (year) and then on **Oct** (month).
      - In the **October 2017** window, click on **11**(date).
      - Select **MODIS Aqua** and **VIIRS Suomi-NPP**.
      - Instead of **Select one or more window**, enter coordinates around the SeaBASS data in **specify boundary coordinates or a single location**.
      - Click on **Find swaths**.



Download MODIS and VIIRS Level-1A Images

14. Several swaths for MODIS and VIIRS for the selected date and region will be displayed.
15. Click on the MODIS and VIIRS swaths in which the SeaBASS data are located.
    - You will be provided with a selection of image file names, Quasi True Color images, and L1A and L2 mage data.
    - Click on **L1A** file and save to your computer.
    - MODIS files will be compressed (.bz2).
    - Double-click on the filename on Mac to unzip or use use bzip2 command on Linux/Windows.

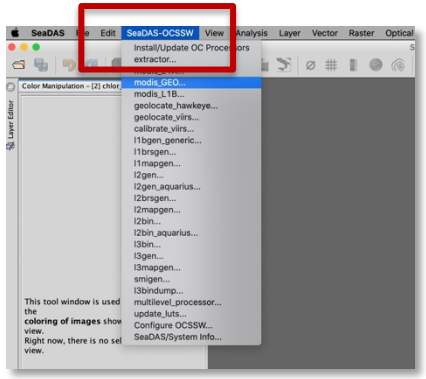


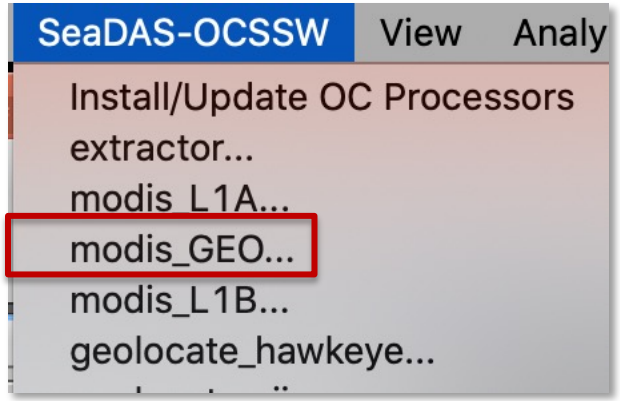
MOD00.P2017284.1815_1.PDS
A2017284181500.L1A_LAC
A2017284181500.L2_LAC_OC.nc
A2017284181500.L2_LAC_IOP.nc
AQUA_MODIS.20171011T181510.L2.SST.nc

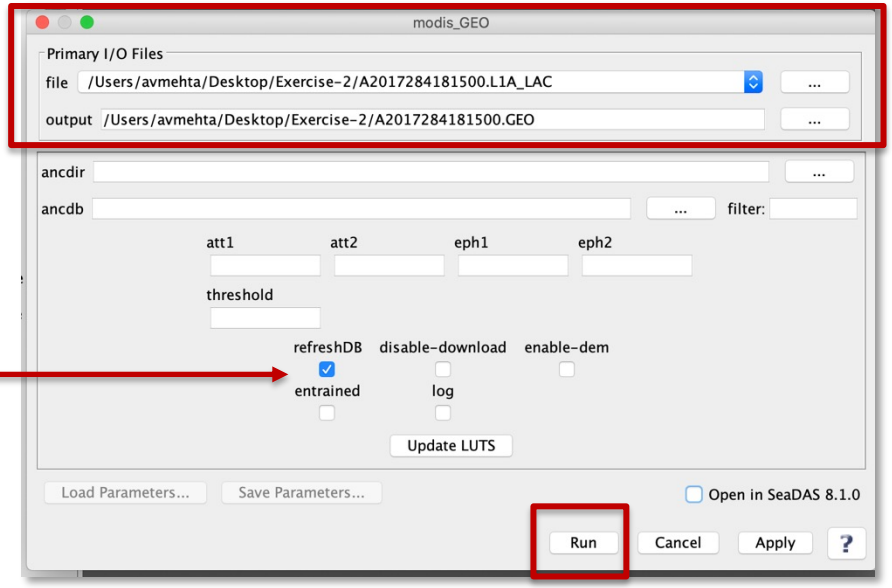
V2017284191200.L1A_SNPP.nc
V2017284191200.GEO-M_SNPP.nc
V2017284191200.L2_SNPP_OC.nc
V2017284191200.L2_SNPP_IOP.nc

Process MODIS Geolocation File for Level-1A Image

16. Use the downloaded L1A swath for MODIS **A2017284181500.L1A_LAC**.
17. Open SeaDAS and make sure you have OCSSW installed in SeaDAS.
18. On the top ribbon, click on **SeaDAS-OCSSW** to get a drop-down list of options.
    - Select **modis_GEO**.
    - A window will open.
    - In **Primary I/O Files → file →** click on (…) and select **A2017284181500.L1A_LAC**.
    - The **output** filename will be populated as **A2017284181500.L1A.GEO**.
    - Select **refreshDB**.
    - Click **Run** at the bottom.







Process MODIS Geolocation File for Level-1A Image

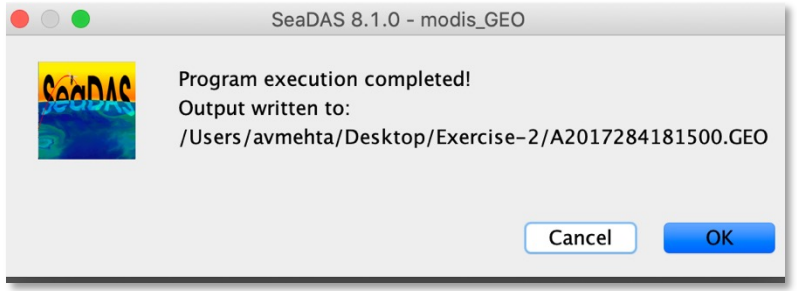
- If you experience an error message when generating the **A2017284181500.L1A.GEO** file, refer to the **Download Methods** instructions at webpage below to configure your username and password for authentication using a .netrc file.

  https://oceancolor.gsfc.nasa.gov/data/download_methods/#download_sec

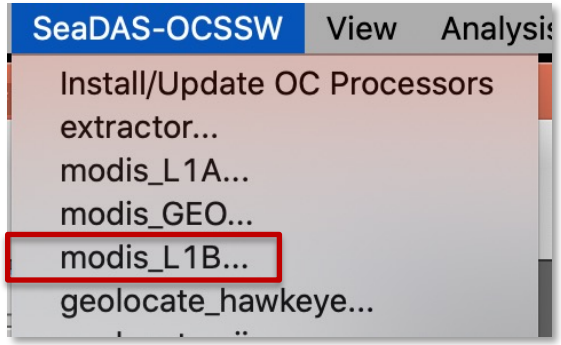
- We've also provided the **A2017284181500.L1A.GEO** file in the zipped folder for Exercise 2.

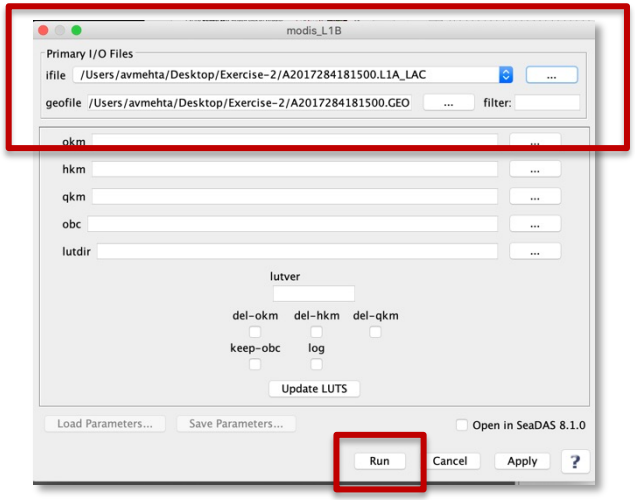
Process MODIS Level-1B from MODIS-1A Image

- A message window appears when the processing is complete, click **OK**.
- The MODIS geolocation file will be saved in the same directory as the L1A file.



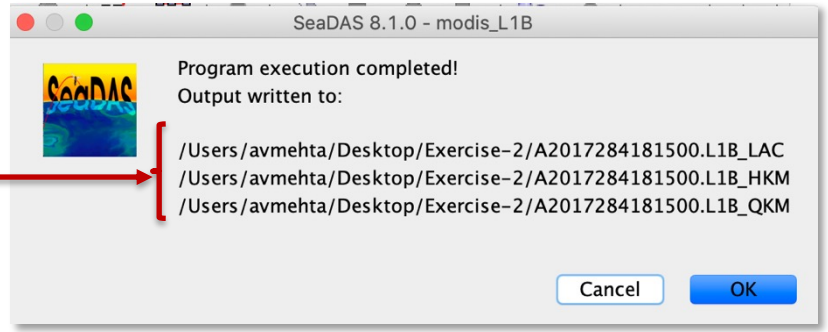
19. From **SeaDAS-OCSSW** drop-down list
    - Select **modis_L1B**.
    - A window will open.
    - In **Primary I/O Files → File →** click on (…) and select: **A2017284181500.L1A_LAC**.
    - The **geofile** will be populated with **A2017284181500.L1A.GEO**.
    - Click **Run**.





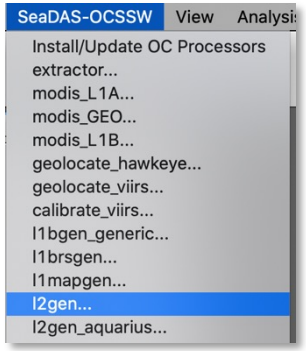
Process MODIS Level-1B from MODIS-1A Image

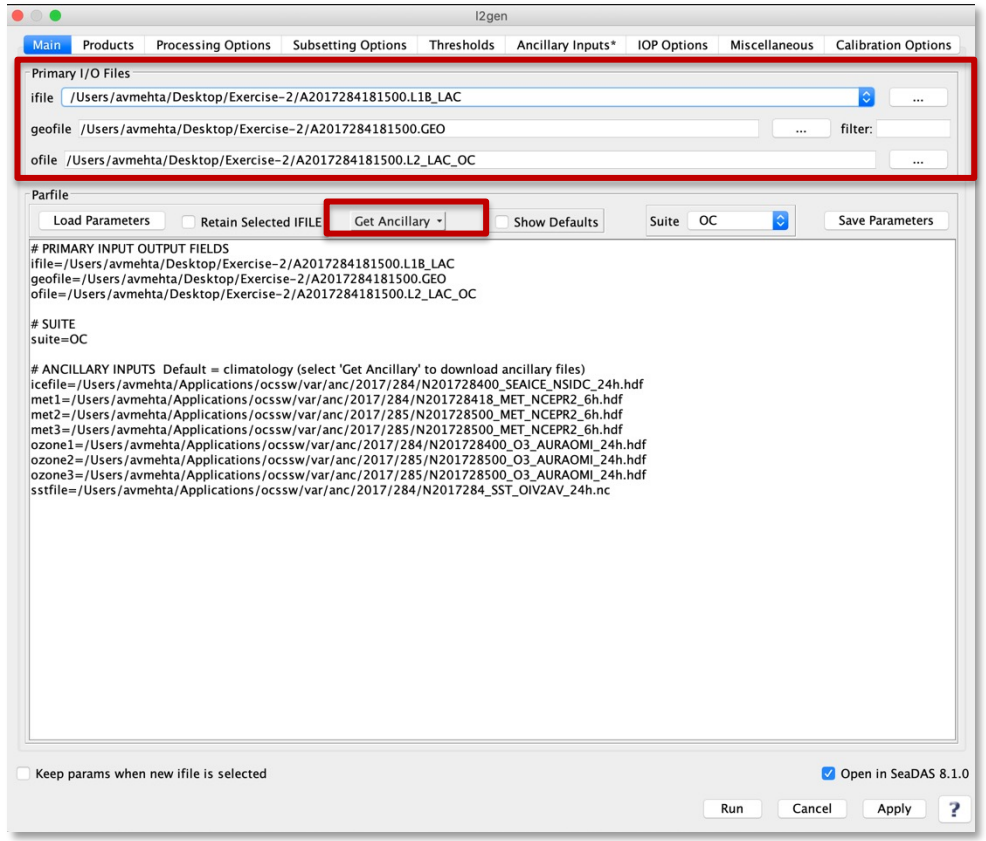
- A message window opens when the processing is complete, click **OK**.
- You will see the the three L1B files in the same same directory as the L1A file.
- The **L1B_LAC** file now can be used to derive MODIS Level-2 geophysical parameter data.



Process MODIS Level-2 Data

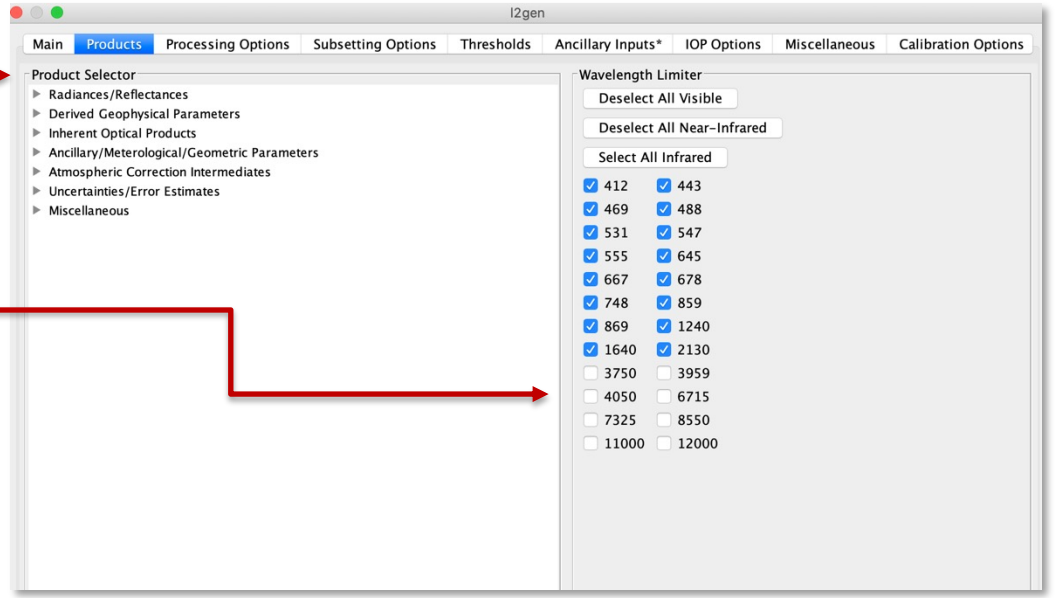
20. From the **SeaDAS-OCSSW** drop-down list, select **l2gen**.
    - A window with multiple options will open.
    - In **Primary I/O Files → ifile →** click on (…) and select **A2017284181500.L1B_LAC**
    - The **geofile** and **ofile** will be populated.
    - Level-2 file will be: **A2017284181500.L2_LAC_OC**
    - Click on **Get Ancillary** if you want the data for atmospheric correction of reflectance for the same date. Otherwise, the default climatological data will be used.





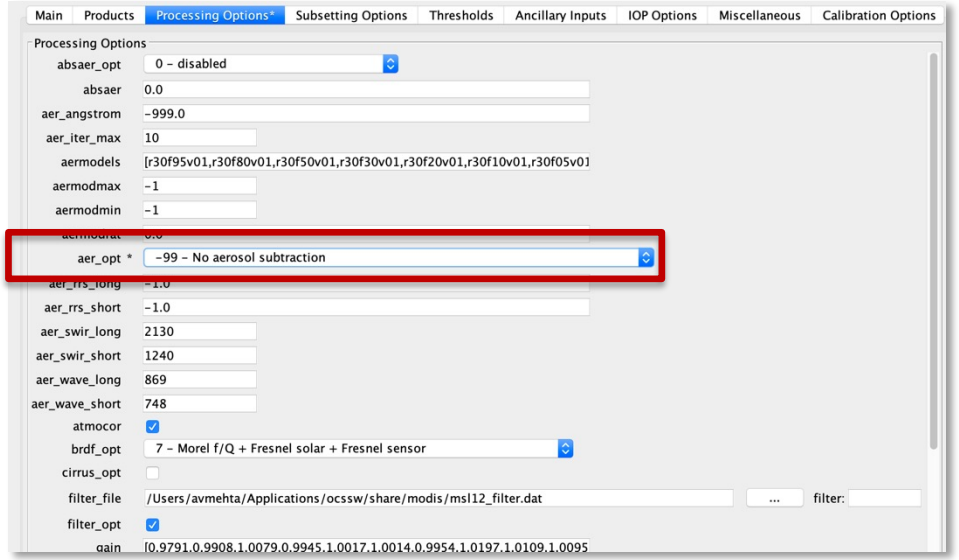
Process MODIS Level-2 Data

21. Click on the **Products** on the top of the **l2gen** window.
    - Explore **Product Selector** options.
    - Deselect **All Infrared** wavelengths.



Select MODIS Level-2 Data Processing Options

22. Click on the **Processing Options** on the top of the **l2gen** window.
    - a window will open with a list of options.
    - scroll down to **aer_opt** and select **-99 – No aerosol subtraction**.



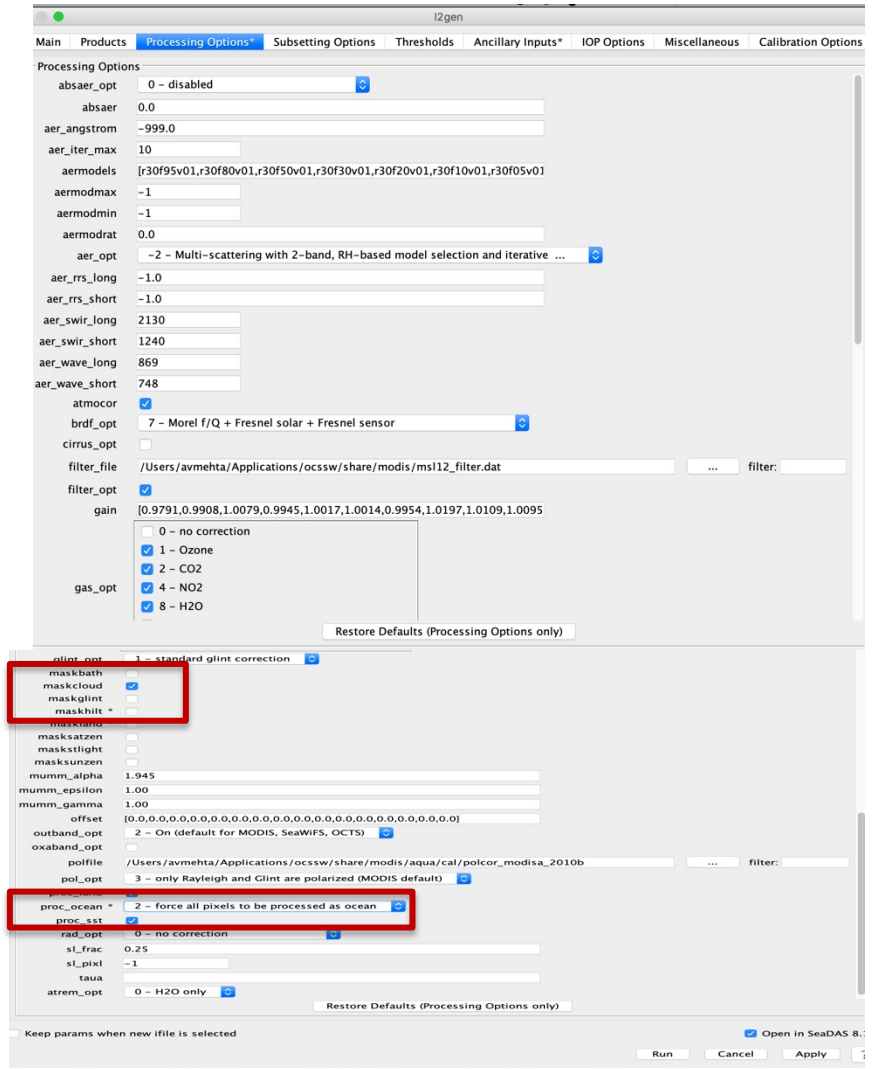
Note: Various aer_opt parameters can be explored to check which atmospheric correction scheme works best for a given region and sensor.

Sometimes atmospheric correction is ignored in optically complex or turbid/shallow waters to avoid uncertainties.

Select MODIS Level-2 Data Processing Options

- Scroll down and deselect **maskcloud**, **maskhilt,** and **maskland**.
- Scroll down further and select **proc_ocean: 2 – force all pixels to be processed as ocean**.
- Click **Run**.

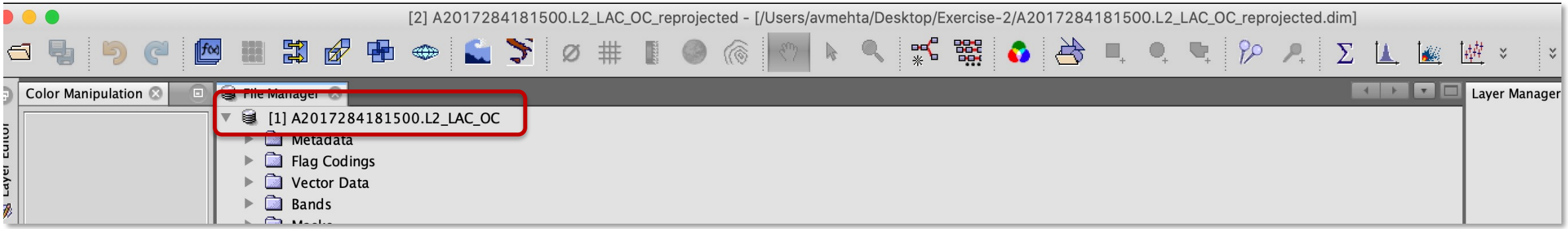
Processing takes a few minutes to complete.



Note: By turning the mask off for cloud, high light, and land pixels, and treating all pixels as ocean, this allows for more data pixels in images and avoids masking coastal pixels as land.

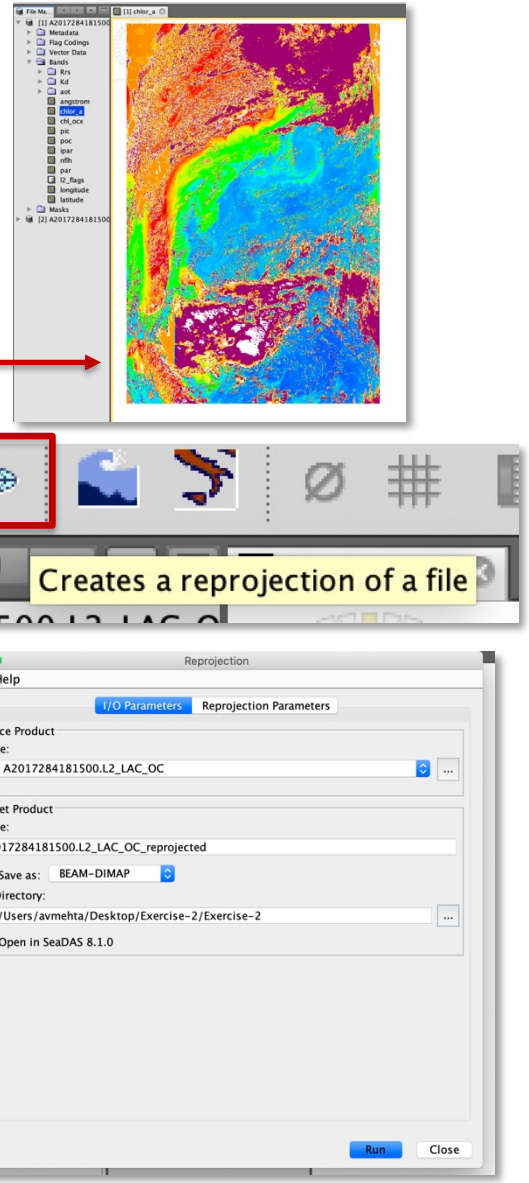
Select MODIS Level-2 Data Processing Options

- A message appears indicating that the L2 processing is complete.
- The L2 file **A2017284181500.L2_LAC_OC** will appear in the SeaDAS **File Manager** and the L2 file is saved in the directory where L1B file is.



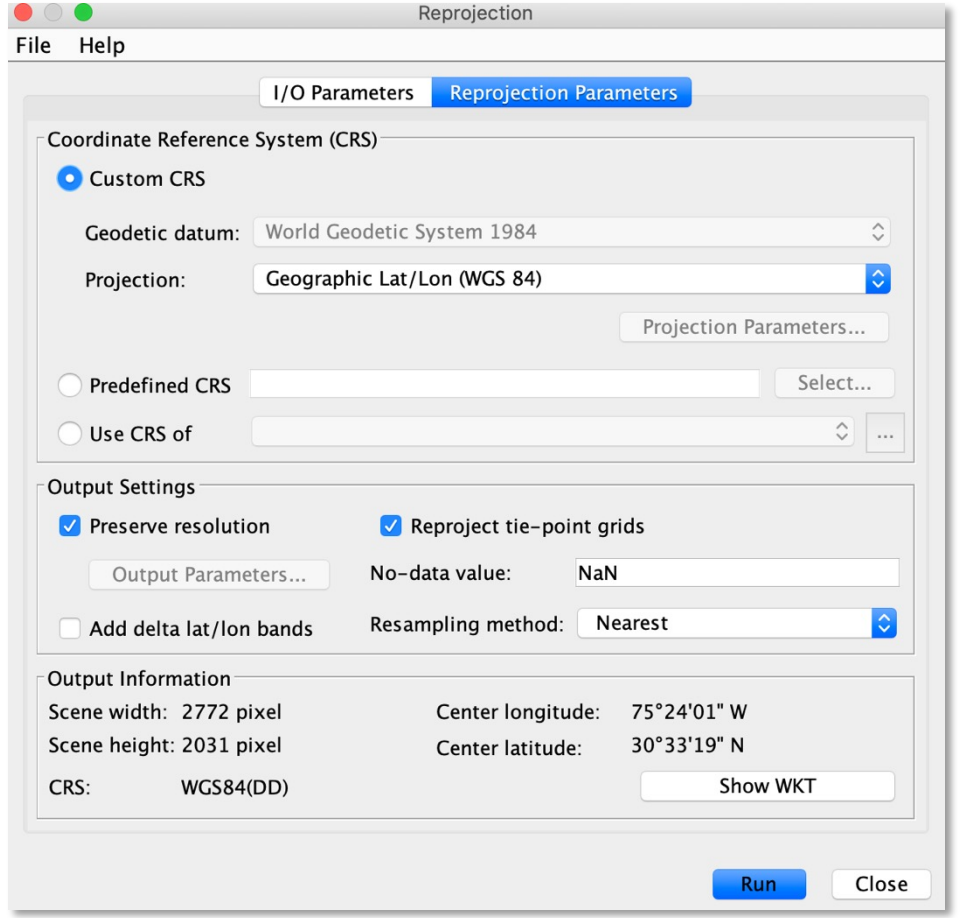
Reproject MODIS Level-2 Data

23. In the **File Manager** window, click on the down arrow next to **A2017284181500.L2_LAC_OC**, and the down arrow next to **Bands**, then double-click to select **chlor_a.**
    - The chlor_a image will be displayed in the SeaDAS window.
    - On the top bar click on the **Create reprojection of a file** symbol.
    - In the **Reprojection** window in **I/O parameters**, select the directory to save the reprojected data.



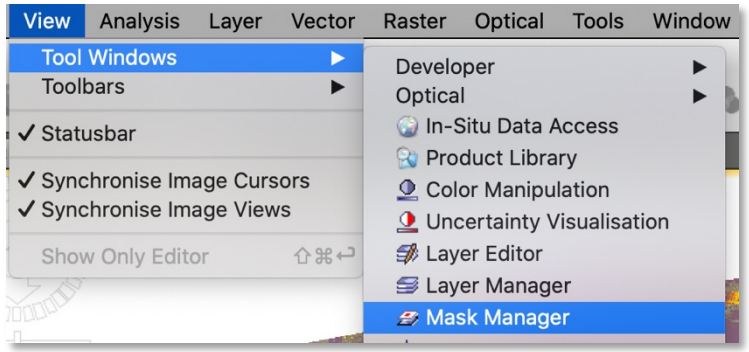
Reproject MODIS Level-2 Data

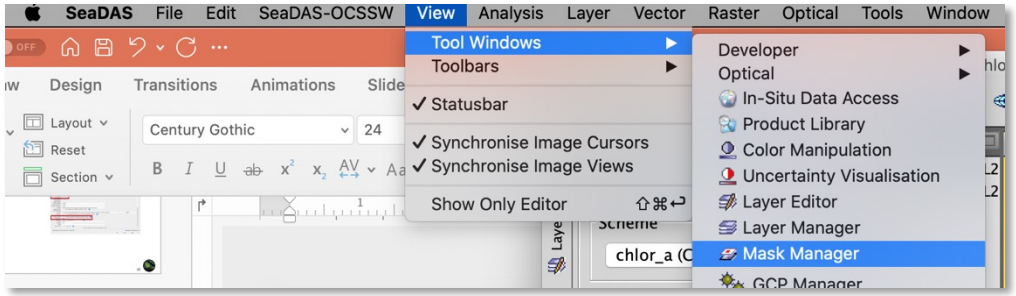
- In **Reprojection Parameters,** under Coordinate Reference System (CRS), **Projection** should be **Geographic Lat/Lon (WGS 84)**.
- Click **Run**.
- When the processing is complete, you will see the reprojected file. **A2017284181500.L2_LAC_OC_reprojected** in the **File Manager**.

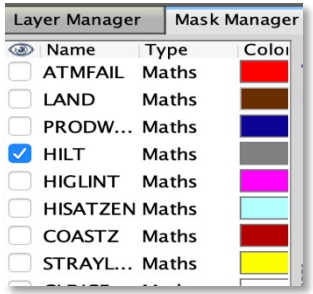


Compare MODIS and SeaBASS Chlorophyll

24. Click on the down arrow next to **A2017284181500.L2_LAC_OC_reprojected**, and the down arrow next to **Bands**, double-click to select **chlor_a**.
    - Reprojected chlor_a image will be displayed in the SeaDAS window.
    - From the top ribbon, go to **View → Tool Windows → Mask Manager**.

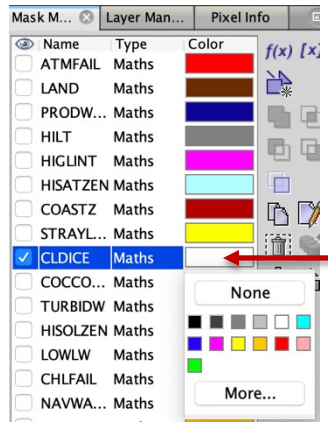






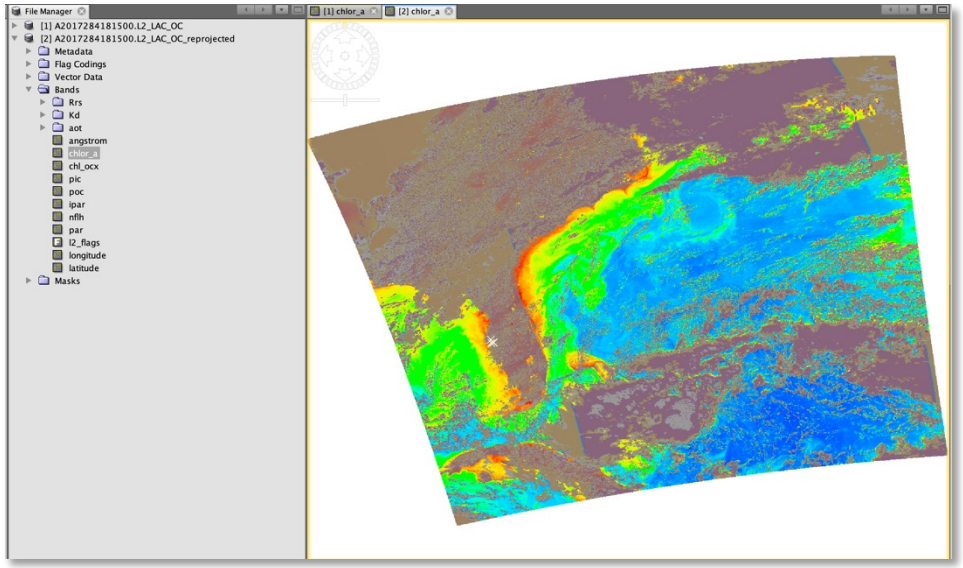
Compare MODIS L2 and SeaBASS Chlorophyll

- The Mask Manager window will open to the right side of the image window.
- Select **CLDICE** mask (choose a color other than white).
- This will mask non-water pixels.
- The L2 chlor_a will be displayed.



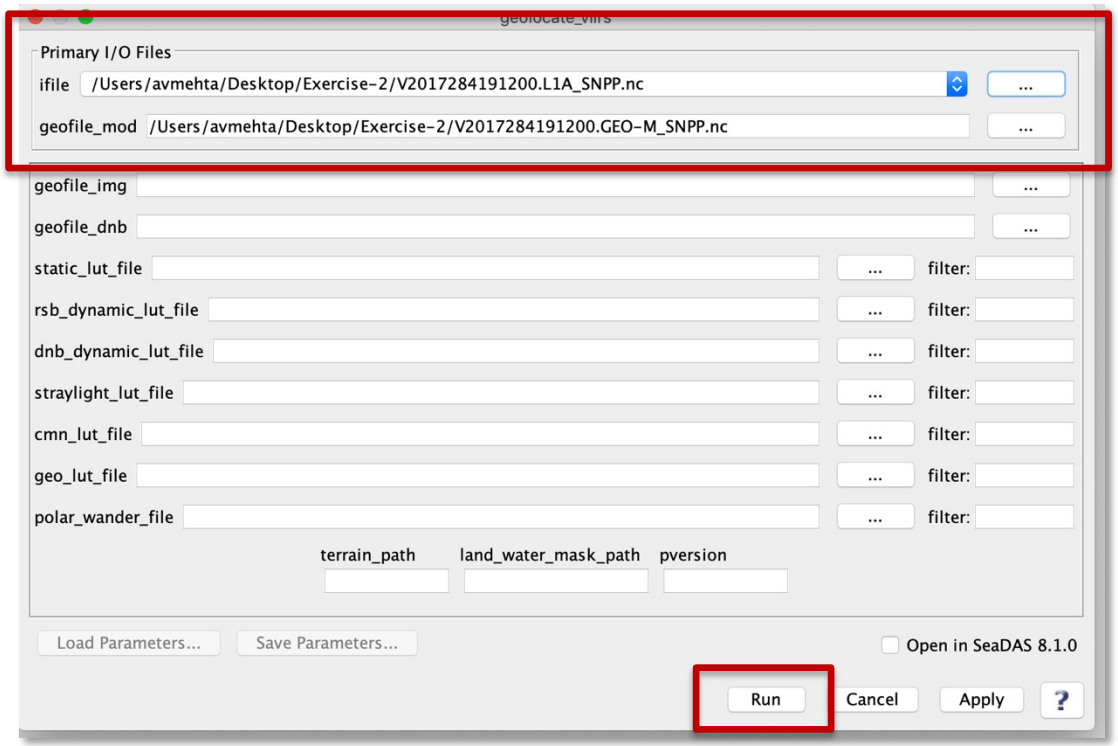
Click to select color

25. Import SeaBASS data to the image following Steps 4 and 5.
    - Follow Steps 7 to 11 to correlate MODIS and SeaBASS chlor_a.
    - Write down R^2.



Process VIIRS Geolocation File for Level-1A Image

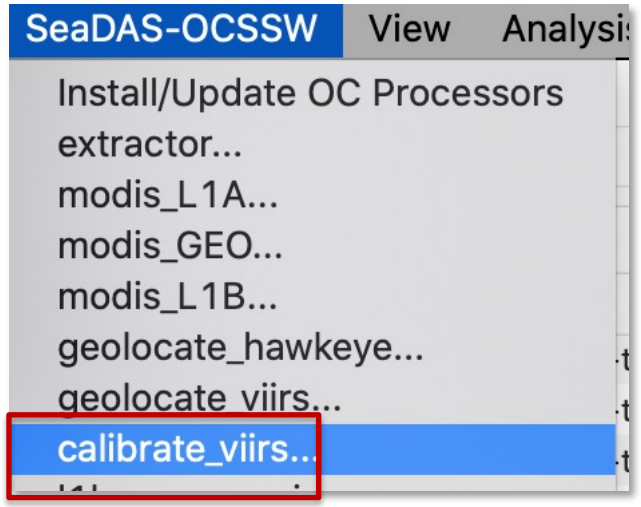
26. Use the downloaded L1A swath for VIIRS **V2017284191200.L1A_SNPP.nc**.
27. In SeaDAS, in the top ribbon click on **SeaDAS-OCSSW** to get a drop-down list of options.
    - Select **geolocate_viirs…**
    - A window will open.
    - In **Primary I/O Files** → **ifile** → click on (…) and select **V2017284191200.L1A_SNPP.nc**.
    - The **output** filename will be populated as **V2017284191200.GEO-M_SNPP.nc**.
    - Click **Run**.

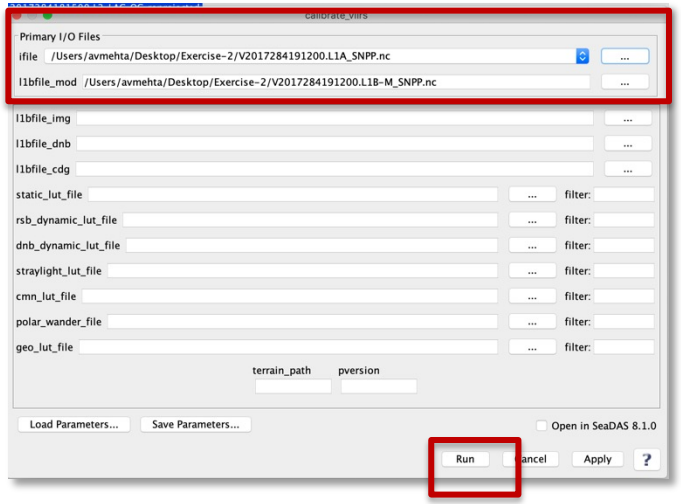


Process VIIRS Level-1B from Level-1A Image

- You will get a message when the processing is complete, click **OK**.
- You will see the GEO file in the same directory as the L1A file.

28. From the **SeaDAS-OCSSW** drop-down list select **calibrate_viirs…**
    - A window will open.
    - In Primary **I/O Files → ifile →** click on (…) and select **V2017284191200.L1A_SNPP.nc**.
    - Click **Run**.





Process VIIRS Level-1B from MODIS-1A Image

- A message window opens when the processing is complete. Click **OK**.
- VIIRS L1B file **V2017284191200.L1B-M_SNPP.nc** is saved in the same same directory as the L1A file.
- The **L1B-M_SNPP** file now can be used to derive MODIS Level-2 geophysical parameter data.

Process VIIRS Level-2 Data

29. Follow Step 20 but use VIIRS L1B file **V2017284191200.L1B-M_SNP.nc** instead of the MODIS L1B file.
    - Follow Steps 21 to 25 to get reprojected VIIRS image.

Note: You will see fringes in VIIRS image before reprojection where the satellite zenith angle is large.

30. Follow Step 7 to correlate VIIRS and SeaBASS chlor_a.
    - Write down R^2.